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General Flow Passage: A Computer Program To Calculate Aerothermal Performance of an Arbitrary Flow Passage of Fixed Geometry

S. C. Skirvin

GENERAL ELECTRIC

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S. C. Skirvin

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(Formerly Aircraft Nuclear Propulsion Department)

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GENERAL FLOW PASSAGE PROGRAM

ABSTRACT

The General Flow Passage computer program calculates the one-dimensional aerothermal performance of a compressible flow passage of arbitrary geometry. The program computes overall temperature and pressure levels as well as local axial pressure and surface temperatures. It will accomodate non-frictional pressure loss coefficients at axial locations as well as at entrance and exit. Both laminar and turbulent flow are treated and internal expansion and contraction losses can be computed by the program. Almost any likely combination of flow and temperature data is acceptable as input data, such as maximum surface temperature or pressure drop. Heat transfer "boundary conditions" are tailored for nuclear heat transfer problems, but not irremediably so.

ACKNOWLEDGEMENTS

The capabilities built into the General Flow Passage program satisfy design calculation requirements which represent the composite experience of many aerothermal designers who have participated in the Aircraft Nuclear Propulsion Project at the General Electric Company. Acknowledgement is made of the advice and information supplied by these people.

In particular, acknowledgement is made of the efforts of J. E. Stankevicz who contributed a number of utility subroutines and participated in check-out and the contributions of R. R. Jordan in the preparation of the present report.

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I INTRODUCTION

The General Flow Passage program (hereafter referred to by the initials "GFP") is a considerably extended growth version of an earlier ANP Department program, the Off-Design Program (reference 2). Both programs utilize the same one-dimensional compressible flow loss analysis as applied to a single flow passage, but GFP accepts a much greater variety of input data and, it is hoped, is much simpler to use.

The Off-Design program was originally conceived for the purpose of providing a fast, convenient method to calculate the off-design-point performance of nuclear reactor cores. It proved to be quite successful for that purpose and, further, has proven to be a real workhorse program for compressible flow calculations for almost any kind of flow passage. Applications have included preliminary sizing and parametric performance calculations for nuclear reactor cores, shield coolant flow determination, analysis of test data, calculation of control rod coolant flow, and many similar tasks.

The shortcomings of the Off-Design program were that; 1) the preparation of the input data was more tedious than necessary, 2) there was no provision for the insertion of non-frictional pressure losses along the length of the flow passage, 3) there was no provision for parametric calculations whereby one or more of the flow variables could be systematically varied by a single record of input data, 4) no sort of summary printout for a group of cases computed during one computer run could be obtained, 5) only fully developed turbulent flow was treated, and 6) only the mass flow, inlet and exit total temperatures, and the inlet total pressure could be specified as input flow and temperature data. The effect of the last restriction was that it proved to be necessary to plot the results of Off-Design cases when it was desired to have a specified exit total or static pressure or a specified maximum surface temperature. By such graphs, the necessary value of the inlet pressure, mass flow, or inlet or exit temperature could be determined.

The GFP program has successfully overcome all of these shortcomings and, hence, represents a valuable tool for the aerothermal designer. It is naturally formulated in terms of the boundary conditions ordinarily used by the nuclear heat transfer designer, but there is no major analytical or logical difficulty in the way of revising the program to accept other types of boundary conditions. This matter is discussed in the Programmer and Analyst Comments section of the present report.

The present report contains a complete listing to the Fortran source deck together with certain SAP-coded subroutines which are not generally available.

II STATUS OF PROGRAM

ANP 7090 DIGITAL PROGRAM No. 663

Title	Engineer	Unit
General Flow Passsage Program (GFP)	S. C. Skirvin (Anal. and Coding)	Fluid Mech.

Computer	Status	Category
IBM 7090 32K memory	Production (very little production useage)	Thermodynamics

SS2 up for input from logical 2, SS2 down for card input. SS3 up for output on logical 3, SS3 down for output on-line.

Abstract

Calculates one-dimensional aerothermal performance of a compressible flow passage of arbitrary geometry. Computes overall temperature and pressure levels as well as local axial and surface temperatures. It will accomodate non-frictional pressure loss coefficients at axial locations as well as at entrance and exit. Both laminar and turbulent flow are treated and internal expansion and contraction losses can be computed by the program. Almost any likely combination of flow and temperature data is acceptable as input data, such as maximum surface temperature or pressure drop. Heat transfer "boundary conditions" are tailored for nuclear heat transfer problems.

References

Skirvin, S. C., "General Flow Passage: A Computer Program to Calculate Aerothermal Pefformance of an Arbitrary Passage of Fixed Geometry (ANP 663)" GE ANPD APEX 664, 8/61

Additional Remarks

Program is on file with: Communications Specialist
General Electric Company
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Cincinnati 15, Ohio

III MATHEMATICAL AND LOGICAL ANALYSIS

As was noted in the Introduction, the GFP program utilizes the same compressible flow loss analysis as did the Off-Design program described in reference 2. The pertinent equations will be described below, for the sake of completeness.

A considerably different analysis was employed for the calculation of surface temperature in GFP because the iterative method used in the Off-Design program proved to be unstable when direct thermal property values were used. (The Off-Design program utilized air properties implicitly expressed in the turbulent Nusselt Number correlation as exponential functions of temperature.) A numerical root-finding technique was used instead in GFP.

The same root-finding technique is used in more general form in the iterations which enable the GFP program to calculate, say, the weight flow required to produce a specified maximum surface temperature even though the latter is a function of the former.

In addition to the above major items, sufficient explanatory material is provided to answer most, if not all, of the questions about the contents of the GFP program which might arise.

III.1 Compressible Flow Loss Analysis

The stage exit bulk (total) temperature for the n-th stage is computed from the power profile by

$$T_{exi,n} = T_H\left(\phi_{i,n}\ \Delta H + H_{in}\right) \tag{1}$$

where $T_H(\ )$ is the temperature function of enthalpy and the total enthalpy increase, ΔH, is computed from

$$\Delta H = H_T(T_{t\,ex}) - H_{in} \tag{2}$$

$H_T(\ )$ is the enthalpy function of temperature.

For the n-th stage of finite, non-zero length ΔL_n, the pressure drop due to friction and heat addition can be expressed, following reference 6, as

$$P_{exi,n} = P_{ini,n}\ e^{-\frac{\gamma}{2} M_{av,n}^2 \left(\ln \frac{T_{ex,n}}{T_{in,i}} + \frac{4 f_n \Delta L_n}{D_{h,n}}\right)} \tag{3}$$

which is an approximate, integrated form of a differential equation in the reference cited. The average Mach number over the length ΔL is assumed to be given by

$$M_{av,n} = \frac{M_{in,n} + M_{exi,n}}{2} \tag{4}$$

The inlet and exit Mach numbers are both calculated by iteration from the relation

$$M = \frac{G}{P_T}\sqrt{\frac{R T_T}{\gamma g}}\left[\left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma+1}{2(\gamma-1)}}\right] \tag{5}$$

Equation (5) is evaluated by the Fortran function AMACH.

The iterative loop represented by equations (3) thru (5) is contained in the subroutine DPFRLT. The sequence of calculations is to assume an exit total pressure, calculate the exit Mach number with function AMACH, evaluate the average Mach number with equation (4), and calculate the exit total pressure with equation (3). If the assumed and calculated values of exit total pressure agree within a specified fractional tolerance, the iteration is finished. Otherwise, the newly calculated exit total pressure is assumed for the next iteration loop. A nominal counter limit is installed in the iteration loop.

The fully-developed friction factor, f, is calculated from a standard correlation form

$$f = d\ N_{Re}^{\ e} \tag{6}$$

where the coefficient "d" and the exponent "e" are supplied by the user for

both the laminar and turbulent flow regimes. Transition is assumed to occur abruptly at N_{Re}= 2300 and non-fully developed flow effects (entrance length effects) can be simulated as explained on the input data forms and in the User's Instructions. The friction factor correlations are always assumed to be based on bulk temperature properties. The mean Reynolds number for the stage is used in equation (6).

Stage exit dynamic pressures are computed from the equation

$$P_{dyn,n} = \frac{R}{2g} \frac{G^2 T_T}{P_T} \left[\left(1 + \frac{\gamma - 1}{2} M^2 \right)^{\frac{1}{\gamma - 1}} \right] \qquad (7)$$

which is incorporated into the Fortran function DYPRS.

When an interstage total pressure loss is to be calculated as a fraction of the local dynamic pressure, the appropriate coefficient is multiplied times the dynamic pressure computed function DYPRS. When the appropriate loss coefficient is to be computed by the program if an area change occurs from one stage to the next, the Fortran function LOSS is used to carry out the computation.

Both entrance and exit losses are computed by the method just described, utilizing the appropriate coefficients.

When stage exit static pressures are to be computed, the equation

$$P_{exit,n} = P_T \left[\left(1 + \frac{\gamma - 1}{2} M^2 \right)^{\frac{\gamma}{1-\gamma}} \right] \qquad (8)$$

is used. It is incorporated into the Fortran function PSTAT.

III.2 Numerical Root-Finding Technique

The technique to be described has an overwhelming advantage for the present applications in that no analytical relationship need be known between the independent and dependent variables. It is, essentially, a numerical version of the conventional graphical method of extrapolation/interpolation for roots of functions.

In GFP, the inlet total pressure (PTIN) and the mass flow (W) are used as independent variables, depending on which input option is being exercised. Dependent variables can be maximum surface temperature (TWMAX), exit static pressure (PSEX), or exit total pressure (PTEX). A special application of the technique is made in calculating surface temperature, as has been noted.

Before the root-finding technique can be applied, two values of the independent variable and the corresponding values of the dependent variable must be available. The generation of "starting values" is described in the section with that name.

The second value of mass flow when the dependent value is the maximum surface temperature is calculated from

$$W_{est,2} = W_{est,1} \left(\frac{T_{wmax-calc,1}}{T^*_{wmax}} \right)^{1.25} \tag{9}$$

where the asterisk denotes the desired value. When the exit static or total pressure is the dependent variable, the second value of mass flow is calculated from

$$W_{est,2} = W_{est,1} \left[\left(P_{tIN} - P^*_{ex} \right) / \left(P_{tIN} - P_{ex-calc,1} \right) \right]^{1.25} \tag{10}$$

The second value of inlet total temperature (with which exit static or total pressure is always the dependent variable) is calculated from

$$P_{tIN-est,2} = P_{tIN-est,1} \left(\frac{P^*_{ex}}{P_{ex-calc,1}} \right) \tag{11}$$

When the two values each of the independent and dependent variable have been obtained, the next estimate of the independent variable is obtained by linear extrapolation from

$$x_3 = \left(\frac{x_2 - x_1}{y_2 - y_1} \right) \left(y^* - y_2 \right) + x_2 \tag{12}$$

where x and y are independent and dependent variables respectively, the asterisk denotes the desired value as before, and the subscripts refer to the sequential order of the estimates and the corresponding yields of the dependent variable.

Once three sets of values have been obtained and thereafter during the root-finding procedure, the next estimate of the dependent variable is always calculated by a quadratic extrapolation/interpolation which fits a parabola through the last three points calculated and uses the intersection of that parabola with the line $y = y^*$ as the next estimate of the independent variable. The parabola has its axis parallel to the "x-axis" in order to obtain single-valued results. The $i + 1$ estimate of the root (value of the independent variable) is calculated from

$$x_{i+1} = \bar{a} + \frac{(y^* - \bar{b})^2}{4\bar{f}} \tag{13}$$

The fitted parabola is calculated from the relations

$$\bar{b} = \frac{(y_i^2 - y_{i-2}^2)(x_{i-1} - x_{i-2}) - (y_{i-1}^2 - y_{i-2}^2)(x_i - x_{i-2})}{2\left[(y_{i-2} - y_{i-1})(x_i - x_{i-2}) - (y_{i-2} - y_i)(x_{i-1} - x_{i-2})\right]} \tag{14a}$$

$$4\bar{f} = \frac{(y_i^2 - y_{i-2}^2) + 2\bar{b}\,(y_{i-2} - y_i)}{x_i - x_{i-2}} \tag{14b}$$

$$\bar{a} = x_i - \frac{(y_i - \bar{b})^2}{4\bar{f}} \tag{14c}$$

Equations (12 thru (14) are coded in the subroutine EXTRAP. Convergence on the desired root is recognized for exit pressures when the fractional tolerances ACCPRS is satisfied and for surface temperatures when the absolute tolerance ACCTMP is satisfied.

III.3 Starting Values

No provision has been made for the user to load a starting value for the inlet pressure, when it is the independent variable. A starting value may or may not be loaded for mass flow. For the first case of a given computer run, the compressible flow function is used in one of the following forms when a starting value is needed:

For mass flow,

$$W = AM\sqrt{\frac{\gamma g}{R}}\,\frac{P_T}{\sqrt{T_T}}\left(1+\frac{\gamma-1}{2}M^2\right)^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{15}$$

in which a Mach Number of 0.1 is assumed. Equation (15) is contained in the Fortran function FLWFUN.

For inlet pressure,

$$P_T = \sqrt{\frac{R}{\gamma g}}\,\frac{W\sqrt{T_T}}{AM}\left(1+\frac{\gamma-1}{2}M^2\right)^{\frac{\gamma+1}{2(\gamma-1)}} \tag{16}$$

in which a Mach Number of 0.1 is also assumed. Equation (16) is contained in the Fortran function PRSFUN.

Subsequent cases will ordinarily use a starting value carried over from a preceding case, unless a new value has been loaded for mass flow in the appropriate circumstances.

III.4 Remedial Action in the Event of Choking (subroutine UNCHKE)

If choking is encountered in one of the input options wherein the user has specified both inlet total pressure and mass flow, no remedial action

is possible; the user has chosen a flow which chokes at the specified pressure level. (Choking is assumed whenever a Mach Number of 0.9 or higher is encountered during calculations.)

For all other input options, a choking remedial action is carried out which adjusts the independent variable in a suitable fashion to remove the choke. The fact that the user has actually specified a set of conditions which lie beyond the choking limit is recognized only by exceeding a suitable counter limit on the number of times a choking remedial can be carried out.

As a preliminary to the root-finding for any of the so-called "iterative options", two bounds, WHI and WLO, are set up which no estimate of the independent variable is permitted to exceed. WHI and WLO can, of course, represent either mass flows or inlet total pressure levels. WHI is either the lowest choking value of mass flow or the lowest non-choking inlet total pressure. WLO is the highest non-choking mass flow or the highest choking inlet total pressure. For mass flow, WHI is initialized by evaluating equation (15) with a Mach Number of 0.9 and WLO is set equal to zero. For inlet total pressure, WLO is initialized by evaluating equation (16) with a Mach Number of 0.9 and WHI is set equal to 10^{30}.

When a choke is encountered, new values of the independent variable are generated by suitable application of the appropriate compressible flow function (equation (15) or (16)) combined with a check to see that such new values lie between WHI and WLO. If these bounds are exceeded, dichotimization is resorted to, wherein the new value of the independent variable is chosen as the mean of WHI and WLO which are themselves constantly updated during the choking remedial.

The detailed procedure is shown in Figure 3 which gives the logical flow chart for the subroutine UNCHKE.

III.5 Calculation of Surface Temperature

The Nusselt Numbers needed for the calculation of surface temperature are determined from standard correlations of the form

$$N_{Nu} = a\, N_{Pr}^{\,b}\, N_{Re}^{\,c} = \frac{h\, D_h}{k} \tag{17}$$

which is intended to yield fully developed values. Mean Reynolds Numbers for the stage are used in equation (17). Values for a, b, and c must be given for both the laminar and turbulent regimes. The question of whether the Reynolds number, N_{Re}, used in equation (17) is to be evaluated for film or bulk conditions is entirely dependent on whether the Nusselt number correlation is based on film or bulk propetties. In the former case, the Prandtl Number and the thermal conductivity would also be evaluated at film temperature, T_f, which is defined by

$$T_f = (T_w + T_b)/2 \tag{18}$$

The film Reynolds Number can be computed from the bulk value by

$$N_{Ref} = N_{Reb} \frac{\mu_b}{\mu_f} \frac{T_b}{T_f} \tag{19}$$

(derivation based simply on using viscosity and density evaluated at film temperature).

A transitional flow regime is assumed to exist between true laminar and turbulent flow, the actual Reynolds Number limits being specified by the program user (values of 2000 and 8000 are otherwise assumed by the program for TRANHL (N_{Re0}) and TRANHU (N_{Re1}), respectively). The Nusselt Number in this region is computed by a curve fit which matches the laminar and turbulent Nusselt Numbers computed at N_{Re0} and N_{Re1}, respectively, and fairs smoothly into the turbulent region (that is, continuous first derivative).

The transition Nusselt Number is computed from the relationship

$$\eta = \frac{N_{Nu}}{N_{Pr}^{0.4} N_{Re}^{2/3}} \tag{20}$$

where the η factor is obtained from the fitted equation

$$\ln \eta = \frac{A}{N_{Re}} + B N_{Re} + C \tag{21}$$

The curve fit coefficients can be written as

$$A = \frac{N_{Re1} N_{Re0}}{N_{Re0} - N_{Re1}} \left[\frac{N_{Re1}}{N_{Re1} - N_{Re0}} (\ln \eta_1 - \ln \eta_0) - (c_T - 1) \right] \tag{22a}$$

$$B = \frac{1}{N_{Re1}} \left[\frac{A}{N_{Re1}} + c_T - 1 \right] \tag{22b}$$

$$C = \ln \eta_0 - \frac{A}{N_{Re0}} - B N_{Re0} \tag{22c}$$

The terms η_0 and η_1 are calculated by evaluating equation (20) at N_{Re0} and N_{Re1}, respectively.. The c_T is the Reynolds Number exponent for turbulent Nusselt Number. The derivation of A, B, and C is described in Appendix C.

The surface temperature can be computed from the basic heat balance as

$$T_w = T_b + \frac{G_n \, \Delta H_n \, \phi_{x,n} \, D_h}{4 \Delta L_n \, h} \tag{23}$$

Obviously, if the appropriate Nusselt Number correlation is based on bulk properties, the surface temperature has been calculated with one application of equation (20). However, if the correlation is based on film temperature which is itself a function of surface temperature, then recourse must be had to some sort of iterative procedure.

During the development of the GFP program, the calculation of surface temperature was attempted by iteration with non-accelerated convergence and with the method-of-secants acceleration technique (reference 7). This was done by correcting the film temperature with new values of surface temperature calculated from equation (23) until the assumed and calculated temperature agreed within the tolerance ACCTMP.

It was found that the iterations were non-convergent in some of the test cases. Therefore, the numerical root-finding technique previously described was adopted with complete success.

For application to the determination of surface temperature, the surface temperature was chosen as the independent variable and the enthalpy change of the fluid in passing thru the stage was chosen as the dependent variable. Convergence was recognized, as before, when successive estimates of surface temperature differed by less than ACCTMP.

The first two estimates of surface temperature were obtained by iteration with equation (23). It should be noted that the heat transfer coefficient used in calculating the enthalpy release must correspond to the surface temperature. This is a somewhat subtle matter during the starting iterations since the sequence of calculation during the actual root-finding is different. The i-th estimate of enthalpy release is calculated from

$$\Delta H_{calc,i} = \frac{4 h_{n,i} \, \Delta L_n \, (T_{w,i} - T_{b,n})}{G_n \, D_{h,n} \, \phi_{x,n}} \tag{24}$$

The design enthalpy release, ΔH^*, is determined for the stage from the power profile and the total enthalpy increase along the passage.

It is evident from inspection of equation (18) that, if the bulk and film temperatures differ appreciably, the film Reynolds Number will differ considerably from the bulk Reynolds Number. Since transitional flow is recognized by inspection of the bulk Reynolds Number and the curve fit described in equations (20) thru (22) is nominally based on bulk Reynolds Numbers, it is also evident that some difficulties might arise when computing transitional Nusselt Number based on film temperature. The arbitrary, but reasonable, choice was made to modify the transition boundary Reynolds Numbers by the "film factor", $\frac{\mu_b}{\mu_f} \frac{T_b}{T_f}$, as used in equation (19) when the corresponding correlation is based on film temperature.

There are some minor discrepancies remaining in both the binary deck and the listed decimal source deck for the TWLT subroutine (Figure 4) in which the preceding equations are incorporated. When only one of the Nusselt Number correlations is based on film temperature and the flow is transitional, all of the transition calculations are based on film temperature, including the modification of both transition-bounding Reynolds Numbers. The effect should be small, but if the program user is concerned, it would be necessary during transitional calculations to check which regime had the correlation based on bulk temperature and then to leave that bounding Reynolds Number unmodified by the "film effect" coefficient and to evaluate the Prandtl Number and Nusselt Number at that boundary at the proper bulk temperature.

Another error or inconsistency which the program user may wish to consider is the fact that the stage-average Reynolds Numbers are used as the bulk Reynolds Numbers, rather than the stage-exit values which would be consistent with the other practices in the analysis. Again, this error would be relatively small, particularly for short stage lengths, but for longer stages it might need to be considered.

III.6 Control of GFP "Iteration" Input Options

There are fifteen distinct input options, thirteen of which are numbered. They are numbered in the order of decreasing priority. When redundant data are loaded (more than needed for any single option) the highest priority option will actually be carried out.

The table below lists the input and calculated variables for the thirteen numbered options.

Option No.	Input Variables				Calculated Variables			
1	PTIN	TTIN	TWMAX	QTØT	PSEX	PTEX	W	TTEX
2	"	"	"	TTEX	"	"	"	QTØT
3	"	"	PSEX	QTØT	TWMAX	"	"	TTEX
4	"	"	"	TTEX	"	"	"	QTØT
5	"	"	PTEX	QTØT	PSEX	TWMAX	"	TTEX
6	"	"	"	TTEX	"	"	"	QTØT
7	PSEX	"	W	QTØT	PTIN	PTEX	TWMAX	TTED
8	"	"	"	TTEX	"	"	"	QTØT
9	PTEX	"	"	QTØT	PSEX	PTIN	"	TTEX
10	"	"	"	TTEX	"	"	"	QTØT
11	PTIN	"	"	QTØT	"	PTEX	"	TTEX
12	"	"	"	TTEX	"	"	"	QTØT
13	"	"	TTEX	QTØT	"	"	"	W

The two remaining options are simply an isothermal pressure drop calculation or a heat transfer calculation without any pressure drop analysis.

Options 1 thru 10 are the so-called "iteration options". In 1 thru 6, the mass flow is the independent variable while the max-average surface temperature, exit static pressure and exit total pressure are, successively, the dependent variables. The inlet total pressure is the independent variable for options 7 thru 10 and, first, exit static pressure, then exit total pressure is the dependent variable. Note also that all odd-numbered iteration options have the heat release specified and hence the exit temperature must be calculated before the compressible loss analysis can be applied.

The first step in controlling the generalized set of iterations involved in the GFP program was to "group" nominally non-subscripted (single-entry) variables into tables for convenience in manipulation. This is done for the major flow and temperature variables shown in Table 1 under the mnemonic "BSI". The individual items included in the BSI-table are shown below:

BSI(i)	Individual Entry Mnemonic
i 1	PTIN
2	TTIN
3	TTEX
4	TWMAX
5	PSEX
6	PTEX
7	W
8	QTØT
9	PSXØPI (PSEX/PTIN)
10	PTXØPI (PTEX/PTIN)
11	TEXØTI (TTEX/TTIN)

It is pertinent to note at this point that a distinction is made in the GFP program between "input" data and "calculation" data. Specifically, "input" data refer to those data which are actually loaded into the program by the user. Such data are, virtually without exception, left intact and unmodified by the program. On the other hand, "calculation" data may refer to input data which have been transferred into other locations than those in which they were originally loaded or to output data from the calculations. The advantage of this scheme is that the user need not reload data for subsequent cases if the particular values are not being changed, since the data have not been "used-up". Furthermore, the original data are also available for later logical control purposes.

The most important example of this practice for the present purposes is the BSØ table. This table has entry points similar to those in the BSI table. It is initially filled from the contents of the BSI table and then the remainder of the table is filled by the result of the option calculations.

The option number, which has the mnemonic KØPT, is chosen by systematic inspection of the BSI table to determine what non-zero values are present. This is accomplished by the double-subscripted variable KØPSET which is dimensioned 3 x 13. This table is filled with fixed point constants (integers) which are used as subscripts in an inspection of the BSI table.

KØPSET(i,j)

	i = 1	2	3
j = 1	1	4	8
2	1	4	3
3	1	5	8
4	1	5	3
5	1	6	8
6	1	6	3
7	7	5	8
8	7	5	3
9	7	6	8
10	7	6	3
11	7	1	8
12	7	1	3
13	1	8	3

All options require TTIN, hence it is inspected for separately. As soon as all three subscript entries are found to be non-zero for some j, KØPT is set equal to that j. (The KOPSET table and determination of KØPT are found in the CONSIS subroutine.)

The KØNØPT table, dimensioned 2 x 10, is used to retrieve the dependent and independent variables from the BSØ table. (This table is set up in the INITAL subroutine, but functions in the ITRCØN subroutine.) Its contents are as follows:

KØNØPT(i,j)

	j = 1	2	3	4	5	6	7	8	9	10	(KØPT)
i = 1	4	4	5	5	6	6	5	5	6	6	(dependent variable)
2	7	7	7	7	7	7	1	1	1	1	(independent variable)

The method by which the calculation options are carried out utilizing the numerical root-finding technique previously described is shown in detail in Figure 2 which gives the logical flow diagram for the ITRCØN subroutine.

III.7 Calculation of Hydraulic Diameter and Free Flow Area

There are five cross section options available in the GFP program. The first of these is general, in that the user loads both the hydraulic diameter and the free flow area for each stage. The four remaining options refer to definite cross-sectional shapes wherein the program will actually take the geometrical data and calculate the hydraulic diameter and free flow area. In the description of each option, the mnemonic is given whose value must be greater than zero for the program to recognize that the particular cross section is being used. These mnemonics are listed in the order of priority; the first non-zero one encountered is the only one the program will recognize.

1) Circular (RØUND).

$$A_{ff} = \frac{\pi}{4} D_h^2 \tag{25}$$

2) Rectangular (RECTNG).

$$A_{ff} = L_w L_h \tag{26a}$$

$$D_h = \frac{2 A_{ff}}{L_w + L_h} \tag{26b}$$

3) Elliptical (ELLIPS).

$$A_{ff} = \pi/4 \; D_{maj} \; D_{min} \tag{27a}$$

$$D_h \approx \frac{4\sqrt{2}}{\pi} \; \frac{A_{ff}}{\sqrt{D_{maj}^2 + D_{min}^2}} \tag{27b}$$

4) Concentric annuli (RINGS). The number of rings here is actually the number of full-thickness rings plus two half-thickness rings. The two half-rings lie adjacent to the I.D. and O.D. and within the region between these diameters.

$$D_h = \frac{D_{outer} - D_{inner}}{n-1} - 2\, t_{ring} \tag{28a}$$

$$A_{ff} = \frac{n\pi}{8} \; D_h \left(D_{outer} + D_{inner}\right) \tag{28b}$$

See Item 3 in the User Instruction for a description of distribution of stagewise geometry values.

III.8 Pressure Losses Resulting From Sudden Expansions and Contractions

The mnemonic AUTØLS signals the program that expansion or contraction losses are to be calculated whenever a flow area change is encountered. These calculations are carried out in the subroutine LØSS using the incompressible loss equations described below. The equations were taken from an internal General Electric report, but the results are similar to those described in reference 5.

In the equations below, the subscript 1 refers to upstream conditions while 2 refers to downstream. The dynamic pressure is denoted by q and the loss coefficient by C_L.

1) Contraction loss.

$$\xi = 1 - \left[\left(\frac{2 + A_2/A_1}{5.1415927}\right) \sqrt{1 - \frac{A_2}{A_1}}\right] \tag{29}$$

$$C_L = \left[(1/\xi - 1)/(A_2/A_1)\right]^2 \text{ based on } q_1 \tag{30a}$$

or

$$C_L = (1/\xi - 1)^2 \text{ based on } q_2 \tag{30b}$$

Equation (30a) is the one actually used by the GFP program for contraction losses, since the downstream compressible dynamic pressure required by equation (30b) would require an extra iteration

2) **Expansion loss.**

continued on next page

$$C_L = \left[1 - \left(A_1/A_2\right)\right]^2 \text{ based on } g_1 \tag{31a}$$

or

$$C_L = \left[\left(A_2/A_1\right)^2 - 1\right]^2 \text{ based on } g_2 \tag{31b}$$

Equation (31a) is employed by GFP for the same reason mentioned above.

III.9 Logical Control For Parametric Studies

Parametric cases are those in which one or more of the flow and temperature variables are systematically varied over an incremental range of values. There is no limit on how many parametric "points" can be generated by a single record of input data. All successful parametric calculations are automatically printed out in the summary tables.

As would be deduced from the previous discussion of the logic used to control the iterations, parametric control is also accomplished by proper grouping of variables and by a table filled with suitable subscripts.

All eight of the so-called flow and temperature variables can be incremented in this fashion, although obviously only those occurring as input data for the current input option will be active. The increment mnemonics themselves are designated by prefixing the letter "D" to the regular input mnemonics. The mnemonics generated by prefixing either "NØ" or "N" to the regular input mnemonics are used to signal the number of times the original value of the variable is to be incremented plus one.

Increment mnemonics are grouped in the tables DPARAM (input) and DPARMR (calculation). Increment counters are grouped in the tables KPARAM (input) and KPARMR (calculation). All of these tables are ordered to correspond to the BSØ table so that a single subscript supplies access to corresponding quantities in all of the tables.

The actual stepping of the running counters, resetting counters, and incrementing and restoring the variables themselves are accomplished with the KØNPAR table which is dimensioned 4 x 13 (4 variables for each option) and filled with fixed point constants. Its contents are

KØNPAR(i,j)

	j = 1	2	3	4	5	6	7	8	9	10	11	12	13
i = 1	8	3	8	3	8	3	8	3	8	3	8	3	8
2	4	4	5	5	6	6	7	7	7	7	7	7	3
3	2	2	2	2	2	2	5	5	2	2	2	2	2
4	1	1	1	1	1	1	2	2	6	6	1	1	1

The detailed program logic for parametric studies is shown in the logical flow chart in Figure 5.

III.10 Entrance Length Effects

The relationships used to calculate the entrance length effects (that is, non-fully developed flow) on heat transfer and wall friction were developed by R. T. Lancet and, as was the case for the transitional heat transfer relationships previously described, they were originally presented in an internal General Electric Company report. The relationships will be presented below without discussion, although the sources of data originally considered by Lancet are referenced.

The Nusselt Numbers calculated with equation (17) are fully-developed values and are designated by the ∞- subscript. Similarly, fully developed friction factors are computed from user-supplied correlations of the form

$$f_\infty = d\, N_{Re}^{\ e} \tag{32}$$

for both the laminar and turbulent regimes. Transition for frictional purposes is assumed to occur sharply at a Reynolds Number which can be designated by the user (the program will assume 2300 if no value is loaded as input data).

Entrance length effects on laminar heat transfer ($N_{Re} \leq N_{Re0}$) are computed from the equation (reference 3)

$$N_{Nu} = \left[N_{Nu\infty}^{3} + 1.56\ \frac{\pi}{4}\ N_{Re}\ N_{Pr}\ (D_h/X) \right]^{1/3} \tag{33}$$

Entrance length effects on turbulent ($N_{Re} \geq N_{Re1}$) heat transfer are computed from the equation (reference 1)

$$N_{Nu} = 1.5\ N_{Nu\infty}\,(D_h/X)^{.16} \quad \text{if } X/D_h \leq N_{Re}^{1/4} \tag{34a}$$

or from

$$N_{Nu} = N_{Nu\infty} \qquad \text{if } X/D_h > N_{Re}^{1/4} \tag{34b}$$

Entrance length effects on laminar friction factor ($N_{Re} \leq N_{ReT}$) are computed from

$$f = f_\infty \left[1 + \beta_1\ N_{Re}\,(D_h/X) \right] \tag{35}$$

For turbulent friction factor ($N_{Re} > N_{ReT}$), the entrance length effects are computed from

$$f = f_\infty \left[1 + \beta_2\,(D_h/X) \right] \tag{36}$$

Both equation (35) and (36) are based on data and discussions in reference 4. Lancet recommended values of 0.005 for β_1 and 10.0 for β_2.

IV LOGICAL ORGANIZATION OF THE GFP PROGRAM

The sequence of operations in the GFP program, apart from initialization, is as follows:

1. Load input data (SR READIN)
2. Process input data (SR DATPRØ)
3. Check input data for consistency and adequacy (SR CØNSIS)
4. Print out input data (SR INPPRT)
5. Carry out calculations if no input errors found (SR ITRCØN)
6. Print out results of calculations (SR ØUTPUT and/or SUMPRT)
7. Reset data fields for next calculation. Return to 1).

Virtually all data are in CØMMØN storage and are "fixed" in CØMMØN by means of EQUIVALENCE statements. This is very convenient when it is desired to rearrange the storage map. Since large blocks of mnemonics can be relocated en masse without revising long lists attached to CØMMØN statements. In addition, it provides complete freedom of action in the use of further EQUIVALENCE statements.

V USER INSTRUCTIONS

V.1 Instructions

Introduction

The General Flow Passage computer program (ANP 663, for the IBM 7090) calculates the subsonic compressible pressure losses and associated temperature levels for a single flow passage of arbitrary geometry filled with any one of a variety of flowing gases. The program contains many features which enable it to satisfy most reasonable design restraints without the necessity for cross-plotting of results and which enable the user to avoid the need for redundant entry of data.

General Flow Passage is intended as a complete replacement for the Modified Off-Design program (ANP 443) which exists only for the IBM 704 and is a much more primitive program.

Definitions

Flow passage - Any series or connected group of flow elements, either components and/or enclosed flow channels, all characterized by carrying the same mass flow.

Stage - Any individual element of a flow passage. Usually, a stage refers to an incremental length along an enclosed flow channel, but zero length stages can be used to simulate arbitrary flow elements, such as valves and orifices, but means of user-specified total pressure loss coefficients.

Case - A complete pressure loss and heat transfer calculation for all stages of a flow passage.

Record of input data - All data included between cards bearing end-of-record punches. Except for some special option control variables, should normally include all original or changed data needed by the program to carry out the desired type of calculation.

End-of-record punch - A column 1 punch which is either an = (equal - sign; 8-3 punch) or an (arrow or dash; 8-4 punch).

Summary of Features

The brief descriptions below are intended only to indicate the capability of the General Flow Passage program. Further explanations will be given later for those features which are not self-evident from the input forms.

Input/Output Units Normally inches (direct and derived quantities) and degrees F. Optionally, feet and/or degrees R can be separately used in input and/or output.

Geometry-Length The passage can be subdivided into as many as 100 increments (ie,"stages") of arbitrary length. Zero lengths are permissible to permit simulation of valves, orifices, etc. Stage lengths can be imputted by individual lengths or by fractional stations of a total length.

Geometry-Cross Section Five options exist:

1. General; user supplies hydraulic diameter and free flow area.

2. Round; user supplies diameter.

3. Rectangular; user supplies height and width.

4. Elliptical; user supplies major and minor axes.

5. Concentric rings; user supplies inner diameter, auter diameter, thickness of rings, and number of rings. (Inner and outer rings are assumed to be of half-thickness.)

Flow and Temperature Input There are fifteen options available which are automatically selected by the program on the basis of the input data. These will be discussed in detail in a later section.

Partial Printout It is possible to have only flow and temperature input and output printed out for each case or to completely suppress the input printout.

Summary Printout The program builds up a table of flow and temperature output and will print out the table upon command or when the program has carried out calculations for 100 cases.

Interstage Losses The user may specify interstage loss coefficients or have the program calculate incompressible loss coefficients (with or without modifying multipliers) when flow area changes occur.

Distribution of Repetitive Stagewise Input A method is provided for sequential distribution of a repetitive variable so that the user does not have to have long strings of identical numbess on the input forms.

Laminar, Turbulent, and Transitional Flow An abrupt transition is assumed for pressure drop (ie, friction factor) at a Reynolds Number which can be designated by the user. For heat transfer, transition is assumed to occur over a Reynolds Number range which can also be designated by the user. Heat transfer coefficient correlations can be based on bulk or film temperatures of the flowing gas.

Entrance Length Effects The program user can have non-fully-developed flow simulated by prescribed relationships which will be described in the analysis.

Parametric Studies An indefinitely large number of cases can be generated from a single record of input data to facilitate parametric studies which require systematic variation of flow and temperature input parameters.

Built-In Data Checking The program has a rather elaborate set of checks to insure that both sufficient and self-consistent input data have been provided. If the program finds that inadequate input data were provided, it will ordinarily not carry out any more calculations (to conserve computer time) and will merely check the remaining input data to insure that there are no DIP-type data which would cause subsequent data loading errors.

An option exists (variable ALLRUN, form 7) which will cause the program to carry out calculations whenever it finds adequate data have been loaded. The user must recognize that, if data are collected piecemeal in this fashion from various input records, the case for which calculations are finally carried out may bear no resemblance to anything the user had in mind. (If the program once finds a DIP-type input error, for instance, none of the remaining data in that record will be loaded into the program.)

Some Detailed Instructions

1. Flow and Temperature Input

As was noted in the introductory remarks, there are 15 distinct input options available in terms of which variables are inputted and which are calculated by the program. In order to describe these options systematically, the following list of input/output variables will be used:

PTIN	Inlet total pressure
TTIN	Inlet total temperature
W	Passage mass flow
TWMAX	Maximum stage-exit surface temperature.
TTEX	Bulk exit total temperature.
PTEX	Exit total pressure
PSEX	Passage exit face static pressure
QTØT	Heat addition to gas in passage (may be negative)

The thirteen major input options are tabulated below.

Option No.	Input Variables				Calculated Variables			
1	PTIN	TTIN	TWMAX	QTØT	PSEX	PTEX	W	TTEX
2	"	"	"	TTEX	"	"	"	QTØT
3	"	"	PSEX	QTØT	TWMAX	"	"	TTEX
4	"	"	"	TTEX	"	"	"	QTØT
5	"	"	PTEX	QTØT	PSEX	TWMAX	"	TTEX
6	"	"	"	TTEX	"	"	"	QTØT
7	PSEX	"	W	QTØT	PTIN	PTEX	TWMAX	TTEX
8	"	"	"	TTEX	"	"	"	QTØT
9	PTEX	"	"	QTØT	PSEX	PTIN	"	TTEX
10	"	"	"	TTEX	"	"	"	QTØT
11	PTIN	"	"	QTØT	"	PTEX	"	TTEX
12	"	"	"	TTEX	"	"	"	QTØT
13	"	"	TTEX	QTØT	"	"	"	W

The option numbers above describe the descending order of priority. In the event that the user has supplied more data than are needed for any single option, the program will select the highest priority option for which sufficient data are present.

Two more relatively trivial options are provided:

#14 - Supply PTIN, TTIN, and W and also a value of TTEX identical to that supplied for TTIN. The program will carry out an isothermal pressure drop calculation.

#15 - Supply PTIN, TTIN, W, and TTEX and also a value of PTEX equal to the value supplied for PTIN. The program will carry out a heat transfer calculation without any pressure drop calculation.

2. Parametric Study Calculations from a Single Record of Input Data

It is possible to generate an indefinitely large number of cases from a single record of input data when it is desired to systematically vary the flow and/or temperature parameters for a passage of fixed geometry.

Two additional pieces of data must be provided for each parameter to be varied; 1) the number of times plus one that the starting value is to be incremented, and 2) the magnitude and sign of the increment. The variable names to be used are shown on input form 6 . If the user neglects to load a non-zero increment for a variable, the program will conserve time by not uselessly incrementing the variable in question.

The order of variable incrementing is that implied in the variable listing previously given for option 1, proceeding from right to left. For example, the order of incrementing for option 7 would be W, PSEX, QTØT, and then TTIN.

3. Distribution of Repetitive Stagewise Input

It frequently occurs that a given piece of stagewise data, such as stage length, will be repeated for many successive stages. To avoid the monotony (and added chance for error) which would arise from the necessity of writing and having keypunched such a series of identical numbers, virtually all tabular input can be distributed over successive stages by means of what are called "distribution variables". These are labeled on the input forms and include NLEN, NDH, NAFF, etc.

Useage of the distribution variables is accomplished by writing pairs of numbers after the appropriate variable. The GFP program (using the subroutine DSTRBL) will take whatever value is found in the stage designated by the first number of each pair and distribute that value into all successive stages up to and including the one designated by the second number of each pair. Examples of this can be found in the input for the sample problems in Section VI.

All tabular input which can be distributed in this fashion appears on the input forms with the name followed by an equals-sign (=). The equals sign is intended to aid in "spotting" values into particular stage locations. When "n =" appears after the name of a variable (where n is an integer), it signifies that the next value is to go into the n-th stage. When "n =" appears after a value rather than after the name of a variable, it signifies that n stages are to be skipped before inserting the next value in a stage.

By way of an example, the following three sets of input data cards will all result in the same stagewise variation of hydraulic diameter:

```
3DH,1 = ,.2,.2,.4,.5,.5,.5,.5,.5,.5,.8,.8,.8,.8,
```

or

```
3DH,1 = ,.2,DH,3 =,.4,.5,DH,10 = ,.8,
4NDH, 1,2, 4,9, 10, 13,
```

or

```
3DH,1 = ,.2,1 = ,.4,.5,5 = ,.8,
4NDH, 1,2, 4,9, 10,13,
```

V.2 Input Data Forms

Input Data Forms for the General Flow Passage
Computer Program (ANP 663)

Analyst ______________________ Phone ____________ Date ____________

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See "General Flow Passage Computer Program (ANP 663)" by S. C. Skirvin, GE-ANPD, Report APEX 664, 8/61 (U) for analyses, instruction, and error printout code.

Note: All variables assumed zero by program unless otherwise noted. All controls inoperative unless values greater than zero loaded.

Optional Identification

1	2	
Punch on one card	2	HEADER,10, (1)

1 2 Up to 59 characters including blanks

4	CASE,	,CASTEP,	,
	Case no. (1)	Increment between case numbers (1)	

Gas Selector

3	GAS,	,

(Assumes air)

1 for air, 4 for H_2, 6 for He, 9 for Ne (presently available)

Input/Output Unit Controls

3	FTIN,	, RNKIN,	,FTØUT,	,RNKØUT,	,
	Feet input	^{o}R input	Feet output	^{o}R output	

Printout Controls

4	PRTALL,	,NØINPT,	,NØGEØM,	,PARPRT,	,NØPRT,	,
	Print all stagewise output	Suppress input data printout	Suppress geometrical input printout	Suppress all stagewise input data and output printout	Suppress all normal printout (but permits summary printout)	

HEAT TRANSFER AND FRICTION CHARACTERISTICS

Heat Transfer Correlations (must have at least coefficients)

3	CØFHLM,	,EXHPLM,	,EXHRLM,	,	(Laminar)
3	CØFHTB,	,EXHPTB,	,EXHRTB,	,	(Turbulent)
	Coefficient	Prandtl No. expon.	Reynolds No. Expon.		

Input Data Forms for the General Flow Passage
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Correlation Reference Temperatures

1 2

4	LMBULK,	,TBBULK,	,	If > 0, use bulk instead of film temperature.
	Laminar	Turbulent		

Friction Factor Correlations (must be present)

3	CØFFLM,	,EXPFLM,	,	(Laminar)
3	CØFFTB,	,EXPFTB,	,	(Turbulent)
	Coefficient	Reynolds No. Expon.		

Transition Reynolds Numbers

3	TRANHL,	,TRANHU,	,TRANSF,	,
	Upper laminar limit (2000)	Lower turbulent limit (8000)	Abrupt frictional transition (2300)	

Transition range for convection

Entrance Length Effects (optional)

4	ENTRNC,	,	If > 0, signals entrance length effects to be calculated.

3	BETA1,	,BETA2,	,	Coefficients for friction effects
	Laminar	Turbulent		

Flow (need not be provided for options 1 thru 6 or for 13)

3	W,	,	(Value loaded for options 1 thru 6 will be used as first guess)

Temperatures (only TTIN must always be loaded)

3	TTIN,	,TTEX,	,TEXØTI,	,TWMAX,	,
	Inlet total	Exit total	TTEX/TTIN	Max-ave surface temp.	

4	MAXTMP,	,	If > 0, TWMAX will be attained at that stage.

Heat Release (Use QTØT alone or QØQBAR and QBAR)

3	QTØT,	,QØQBAR,	,QBAR,	,
	Total heat release	QTOT/QBAR	Reference heat release	

Input Data Forms for the General Flow Passage
Computer Program (ANP 663)

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Pressures (PTIN must be given except for options 6 thru 10)

1	2			
3	PTIN,	,PTEX,	,PTIN,	,
	Inlet total	Exit total	Exit static	

Exit Pressure Ratio (Cannot be used with options 6 thru 10)

3	PTXØPI,	,PSXØPI,	,
	PTEX/PTIN	PSEX/PTIN	

GEOMETRY

4	STAGES,	,

(max of 100)

No. of stages

Stage Lengths

Either

3	LENGTH, =,

Physical lengths

and (optional)

4	NLEN, 1 , , 1

Stagewise distribution variable for LENGTH table

or

3	TØTLEN,	,

Total passage length

and

3	XØL,

Fraction of total length to end of each stage (ie, last value must be one)

Cross Section

4	RØUND,	,RECTNG,	,ELLIPS,	,RINGS,	,
	Round	Rectangular	Elliptical	Concentric rings	

(Maximum of one non-zero value above; general cross section if all zero.)

Input Data Forms for the General Flow Passage
Computer Program (ANP 663)

Analyst ______________________ Phone __________ Date __________

Problem ______________________________ Page _____ of _______

1 2

3	, =,

If general or round load DH(hydraulic diam.); if rectangular load WIDTH; if elliptical load ELPMAJ(major axis); if concentric rings load DØUTER (outer diam.)

4	NDH, 1 , , 1

Stagewise distribution variable for above table

3	, =,

If general load AFF (free flow area); if rectangular load HEIGHT; if elliptical load ELPMIN (minor axis); if concentric rings load DINNER (inner diam.)

4	NAFF, 1 , , 1

Stage wise distribution variable to be used only for AFF (general cross section)

If concentric rings, must also have

3	THICK, =,

Ring thickness

4	NØRING, =,

No. of rings

Entrance and Exit Loss Coefficients (optional)

3	CIN,	,CEX, ,
	Entrance	Exit

Automatic Interstage Losses (optional)

4	AUTØLS, ,	If > 0, generates loss coefficient at area changes

Input Data Forms for the General Flow Passage
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1 2

3	CLSMØD, = ,

Multipliers for automatically calculated loss coeff. (All normally equal to one)

4	NCLSMD, (1) , , (1)

Stagewise distribution variable for CLSMØD table.

Arbitrary Interstage Losses (optional)

3	CLØSS, = ,

Loss coefficients

4	NCLØSS, (1) , , (1)

Stagewise distribution variable for CLOSS table

Power Profile (must be supplied unless running isothermal case with TTEX = TTIN)
either

3	PHISUM,

Fraction of total power released by trailing edge of each stage (ie, integrated)
and

3	PHIEX,

Ratio of trailing edge to stage average power for each stage
or (non-integrated)

3	PO,

Relative power level at stage leading edges.
and

3	P1,

Similar to PO, but for midpoints of stages

Input Data Forms for the General Flow Passage
Computer Program (ANP 663)

Analyst ______________________ Phone __________ Date __________

Problem ______________________ Page ______ of ______

and
1 2

3	P2,

Similar to PO, but stage trailing edges

Parametric Setup

No. of times to be incremented plus one

4	NØPTIN,	,NØTTIN,	,NØTWMX,	,NØQTØT,	,
4	NØPSEX,	,NØPTEX,	,NØW,	,NØTTEX,	,

The letters "NØ" have been added to base variables.

Size of increments

3	DPTIN,	,DTTIN,	,DTWMAX,	,DQTØT,	,
3	DPSEX,	,DPTEX,	,DW,	, DTTEX,	,

The letter "D" has been added to the base variables.

Heat Transfer Coefficient and Friction Factor Stagewise Multipliers (all initialized equal to one)

3	HMULT, =,

Heat transfer coefficient multipliers

4	NHMULT, 1 , , 1

Stagewise distribution variable for HMULT table

3	FMULT, =,

Friction factor multipliers

4	NFMULT, 1 , , 1

Stagewise distribution variable for FMULT table.

Input Data Forms for the General Flow Passage
Computer Program (ANP 663)

Analyst ______________________ Phone __________ Date __________

Problem ______________________ Page ______ of ______

Accuracy Criteria (fractional unless otherwise noted)

1 2

3	ACCMNØ,	,ACCPRS,	,ACCTMP,	,
	Mach No. (0.0001	Pressure (0.0001)	Temperature (0.049 deg)	

Counter Limits

4	LIMTRY,	,LIMCHK,	,LMCHTØ,	,LIMPRS, ,
	Tries to satisfy option iteration (15)	Choke adj. for single value of independent vari- able (10	Total no. of choke adj. for a case (30)	Max. tries for a stage exit pressure or exit surface temp. (20)

Miscellaneous

3	MAXMNØ, ,	Max. Mach No. choke remedial tries to exceed (0.5)

4	ALLRUN, ,	If > 0, program will calculate anytime it finds sufficient data regardless of previous errors.

4	NEWSET, ,	Output from this case will be placed into internal input tables with QBAR = QTØT. (Resets to zero)

End of Record (must be last card of data record)

1 2

Punch this | = | |

Summary Printout

=	PRTSUM,1,

(No other action taken when this piece of data is loaded; causes summary printout of all previous successful cases during run. Resets to zero.)

V.2 **Error Code Printout**

TYPE,LOC	Nature of Error
where 1 n	100 = stage number
n,1	no DH when LENGTH 0
n,2	no AFF when LENGTH 0
n,3	no AFF when LENGTH=0
99,99	Reentry 1st statement of main program without sense light 1 on.
101,1	Missing data; no PIN
101,2	Missing data; no TIN
102,1	Missing data; no CØFFLM
2	Missing data; no EXPFLM
3	Missing data; no CØFFTB
4	Missing data; no EXPFTB
103,1	Missing data; no CØFHLM
4	Missing data; no COFHTB
104,104	Neither pressure drop nor heat transfer requested
105,105	No entrance length effect coefficients; will not stop program (BETA1)
106,106	No BETA2
108,n	XØL(n) less than XØL(n-1)
108,0	No XØL table when TØTLEN > 0
109,0	XØL ≠ 1 for last stage
150,1	Too little data; needed both QTØT and TEX
151,1	No power profile with non-isothermal calculation
152,152	More than 100 stages specified. Prevents all other consistency checking.
160,	Choke troubles leading to convergence failure
1	Not iterating when choke encountered
2	Specified conditions resulted in irreniovable chokes
3	Total no. of choke relief attempts exceeded limit
4	Too many tries for a single-choke relief
170,1	Could not satisfy basic iteration in specified no. of tries
2	Unable to converge with two reductions in pressure tolerance fraction
180,N	Unable to obtain stage exit press. for stage N in LIMPRS tries.

190,N	Unable to obtain trailing edge surface temperature for stage N in LIMPRS tries.
200,1	Failed to carry out calculation when NEWSET > 0.
520,N	Pulled in stage N while iterating for wall temp.
999,1	Pulled in iteration loop for time.

VI SAMPLE PROBLEMS

In a program with as many features as GFP, it would be prohibitive to attempt to demonstrate every feature by a sample problem. In the following examples, however, a fairly extensive sampling has been included.

A listing of the input data cards is given first, followed by reproductions of many of the pages of computer output. Missing pages were essentially duplicates of pages already shown.

```
2HEADER 10  OPTION 1
3GAS 1
3ALLRUN 1
4CASE,2,STAGES,10,CASTEP,2,
3COFHLM,4.23,
3COFHTB,.0205,EXHPTB,.4,EXHRTB,.8,
3COFFLM,16,EXPFLM,-1,
3COFFTB,.046,EXPFTB, .2,
3C1,.75,C2,.75,
3OLSUB,1=,3,DHGSUB,1=,.5,AFFSUB,1=,.19635,
4NOL,1,10,NDHG,1,10,NAFF,1,10,
4LIMPRS 40
3PRTALL,1,
3PTIN,23.45,TTIN,91,TWMAX,1235.16,QTOT,4.7715,
3TWMAX,1237.92,
3P0,1,1,1,1,1,1,1,1,1,1,
3P1,1,1,1,1,1,1,1,1,1,1,
3P2,1,1,1,1,1,1,1,1,1,1,
=
2HEADER 10  OPTION 2
3QTOT,0,TTEX,500,W,.01,
=
3PRTALL 0
2HEADER 10  OPTION 3
3QTOT,4.7715,TTEX,0,PSEX,15.951,W,.01,TWMAX,0,
=
3PARPRT 1
2HEADER 10  OPTION 4
3QTOT,0,TTEX,500,W,.01,
=
3PARPRT 0
2HEADER 10  OPTION 5
3QTOT,4.7715,TTEX,0,PTEX,16.841,W,.01,PSEX,0,
=
2HEADER 10  OPTION 6
3QTOT,0,TTEX,500,W,.01,
=
2HEADER 10  OPTION 7
3QTOT,4.7715,TTEX,0,W,.0478063,PTIN,0,PSEX,15.951,
9 PIND AT 32250
C32250,0,
=
2HEADER 10  OPTION 8
3QTOT,0,TTEX,500,
C32250,0,
=
2HEADER 10  OPTION 9
3QTOT,4.7715,TTEX,0,PSEX,0,PTEX,16.841,
C32250,0,
=
2HEADER 10  OPTION 10
3QTOT,0,TTEX,500,
C32250,0,
=
2HEADER 10  OPTION 11
3QTOT,4.7715,TTEX,0,PTIN,23.45,PTEX,0,
=
2HEADER 10  OPTION 12
3QTOT,0,TTEX,500,
```

```
=
4PRTALL 1
2HEADER 10  OPTION 13
3W 0 QTOT 4.7715
=
3W .25
2HEADER,10,    RINGS
4ROUND,0,
4NDH,1,10,NORING,1=,12,
3RINGS,1,DINNER,1=,.382,DOUTER,1=,2.853,THICK,1=,.023585,
=
2HEADER 10  RECTANGULAR
3W,.01,
=RINGS 0 RECTNG 1 WIDTH 1=,.20 HEIGHT 1=,.25
=W .005
2HEADER 10  ELLIPTICAL
3W 4.78042 2
=RECTNG 0 ELLIPS 1 ELPMAJ 1=,.6 ELPMIN 1=,.4
3AFF,1=,0,
4NAFF 0
2HEADER,10, INTERSTAGE LOSSES
3CLOSS,2=,.5,CLOSS,7=,.75,
4NCLOSS,2,3, 7,9,
3ROUND,1,ELLIPS,0,DH,1=,.5,
3W .03
=
4PRTALL,1,
2HEADER,10, AUTO INTERSTAGE LOSSES
3DH,1=,.4,1=,.5,3=,.4,AUTOLS,1,
4NDH,1,2, 3,6, 7,10,
=
2HEADER,10, MODIFIED AUTO INTERSTAGE LOSSES
3CLSMOD,2=,.75,3=,.75,
=
2HEADER 10  X/L STAGE LENGTH INPUT
4NLEN 0 0
3LENGTH 1=,0 TOTLEN 30
=XOL .1 .2 .3 .4 .5 .6 .7 .8 .9 1
3PRTSUM,1,
=
8
```

THE FOLLOWING CARDS ADDED TO THE OPTION 12 INPUT RECORD ABOVE
RESULTED IN THE PARTIALLY INCLUDED OUTPUT LABELED - PARAMETRIC

```
2HEADER,10, PARAMETRIC
3DPTIN,5,DTTIN,100,DTTEX,100,DW,-.01,
4NOPTIN,2,NOTTIN,2,NOTTEX,2,NOW,2,
```

```
$       XEQ

ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
       (FPT)          (SPH)          (FIL)          LOG            EXP            EXP(3
       SQRT           (DIP)          (TSHM)         (RTN)          (BST)          (IOH)
       (WER)          (TES)          (WRS)          (WTC)          (RCH)
       LMPROP 00150        NOPROP 00206        000000 00253        CONSIS 00456
       CONTMP 01342        DPFRLT 01472        FRCFAC 02562        DATPRO 03025
       INITAL 04212        INPPRT 04523        ITRCON 06777        OUTPUT 10707
       PRTUNT 12514        READIN 13324        RESET  14707        SETYLD 15127
       SUMPRT 15321        TWLT   16215        UNCHKE 20027        GAM    20672
       PRN    21214        R      21534        TC     21661        TMPENT 22202
       VISC   23213        AMACH  23533        DSTRB1 23762        DYPRS  24171
       EXTRAP 24312        FLWFUN 24556        FPRNT  24722        LOSS   25014
       NETERR 25277        POWER3 25355        PRSFUN 25535        PSTAT  25671
       TPINSP 25775        XPRNT  26125        BOTTOM 27105        COLUMN 27070
       NOHEAD 27100        HDING  27061        NEWSET 27052        PAGES  27037
       LINES  27045        RESTO  27035        (STHM) 27352        (STH)  27347
       NOPAGE 27076        ANPIPM 27132        WOT    27442        (FPT)  27600
       EXP    27740        LOG    27653        EXP(3  27625        SQRT   30025
       (TSHM) 30113        (TSH)  30110        (SPH)  30136        (BST)  30431
       (WTC)  30521        (WER)  30470        (RDC)  30600        (RER)  30556
       (RTN)  32264        (FIL)  32253        (IOH)  30616        (TCO)  32535
       (TEF)  32534        (RCH)  32533        (ETT)  32532        (REW)  32531
       (WEF)  32530        (BSR)  32527        (WRS)  32526        (RDS)  32525
       (IOS)  32446        (TRC)  32536        (EXE)  32601        (IOU)  33362
       (DIP)  33406        ERRORA 34624        ERROR  34625        EXIT   35046
       (TES)  35070

         EXECUTION
```

40

Ran 2.022 minutes without parametric

OPTION 1

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 2 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000+00	5.0000-01	1.9635-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

OPTION 1

OPTION 1

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 2 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
2	0.2000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
8	0.8000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
9	0.9000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
10	1.0000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000

OPTION 1

OPTION 1

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 2 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	1.0000	1.0000	1.0000
2	0.	1.0000	0.2000	1.0000	1.0000	1.0000	1.0000
3	0.	1.0000	0.3000	1.0000	1.0000	1.0000	1.0000
4	0.	1.0000	0.4000	1.0000	1.0000	1.0000	1.0000
5	0.	1.0000	0.5000	1.0000	1.0000	1.0000	1.0000
6	0.	1.0000	0.6000	1.0000	1.0000	1.0000	1.0000
7	0.	1.0000	0.7000	1.0000	1.0000	1.0000	1.0000
8	0.	1.0000	0.8000	1.0000	1.0000	1.0000	1.0000
9	0.	1.0000	0.9000	1.0000	1.0000	1.0000	1.0000
10	0.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

OPTION 1

```
          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
   INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE       2     FLOW INPUT DATA (GAS IS  AIR    ,NO  1.)
        * * * WILL EXECUTE OPTION NO  1 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.        , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=    -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)     2.0000+03 TO     8.0000+03
    TRANSITION FOR FRICTION AT    2.3000+03

                TOTAL            STATIC          TOTAL
                PRESS            PRESS           TEMP
   INLET    2.34500+01                            91.00
   EXIT     0.                0.                   0.
   EX/IN       0.                               0.
       PSEX/PTIN =    0.
     WEIGHT FLOW =    0.                HEAT RELEASE =    4.77150+00
     QBAR =    0.            Q/QBAR =    0.
       MAX WALL TEMP =    1237.92 AT STAGE NO    0

  ACCURACIES (FRACTIONAL UNLESS NOTED)
       PRESS        MACH NO    WALL TEMP(DEG)
    10.000-05    10.000-05           0.05

  COUNTER LIMITS ON ITERATIONS
      OPTION ITERATION = 15
      CHOKES/WT FLOW = 10    CHOKES/CASE = 30
      STAGE PRESS AND WALL TEMP = 40
```

OPTION 1

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 2 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78042-02 MAX AVE WALL TEMP = 1237.92 AT STAGE 10

HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.1999+00	0.2777	9.59121+03
EXIT	16.840	15.950	500.0	2.8201+00	0.5056	7.87759+04
IN-EX	6.6098+00		-409.02			
RATIO	0.71813		1.7423	PSEX/PTIN = 0.68018		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.9993-01	22.550(AFTER)
EXIT	7.5000-01	2.1151+00	18.955(BEFORE)

CASE 2 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.30	0.	132.5	1084.4	0.3059	1.12093+05
2	22.03	0.	173.8	1087.6	0.3223	1.06621+05
3	21.74	0.	215.1	1096.1	0.3395	1.01762+05
4	21.43	0.	256.2	1108.9	0.3575	9.74210+04
5	21.09	0.	297.2	1125.0	0.3768	9.35202+04
6	20.73	0.	338.1	1143.8	0.3974	8.99971+04
7	20.34	0.	378.8	1164.9	0.4200	8.68003+04
8	19.92	0.	419.4	1187.8	0.4449	8.38872+04
9	19.46	0.	459.8	1212.2	0.4731	8.12224+04
10	18.96	0.	500.0	1237.9	0.5056	7.87759+04

OPTION 1

OPTION 1

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 2 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR-LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	1.3679+00	20.90	0.		1.0637-04	4.4962-03	2.4346-01
2	1.4888+00	20.50	0.		1.1081-04	4.5414-03	2.4346-01
3	1.6158+00	20.08	0.		1.1493-04	4.5840-03	2.4346-01
4	1.7499+00	19.62	0.		1.1875-04	4.6241-03	2.4346-01
5	1.8924+00	19.13	0.		1.2232-04	4.6620-03	2.4346-01
6	2.0450+00	18.61	0.		1.2566-04	4.6980-03	2.4346-01
7	2.2102+00	18.03	0.		1.2880-04	4.7321-03	2.4346-01
8	2.3909+00	17.41	0.		1.3177-04	4.7645-03	2.4346-01
9	2.5920+00	16.72	0.		1.3457-04	4.7954-03	2.4346-01
10	2.8201+00	15.95	0.		1.3722-04	4.8248-03	2.4346-01

OPTION 2

OPTION 2

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 4 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000+00	5.0000-01	1.9635-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

OPTION 2

OPTION 2

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 4 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
2	0.2000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
8	0.8000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
9	0.9000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
10	1.0000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000

OPTION 2

OPTION 2

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 4 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0.   BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

OPTION 2

```
          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
  INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE       4    FLOW INPUT DATA (GAS IS  AIR   ,NO  1.)
        * * * WILL EXECUTE OPTION NO  2 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.       , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=    -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)     2.0000+03 TO     8.0000+03
    TRANSITION FOR FRICTION AT    2.3000+03

                TOTAL            STATIC          TOTAL
                PRESS            PRESS           TEMP
   INLET     2.34500+01                           91.00
   EXIT      0.                0.                500.00
   EX/IN        0.                              0.
       PSEX/PTIN =    0.
     WEIGHT FLOW =   10.00000-03     HEAT RELEASE =    0.
     QBAR =    0.              Q/QBAR =    0.
       MAX WALL TEMP =    1237.92 AT STAGE NO    0

  ACCURACIES (FRACTIONAL UNLESS NOTED)
       PRESS         MACH NO     WALL TEMP(DEG)
    10.000-05    10.000-05           0.05

  COUNTER LIMITS ON ITERATIONS
      OPTION ITERATION = 15
      CHOKES/WT FLOW = 10    CHOKES/CASE = 30
      STAGE PRESS AND WALL TEMP = 40
```

OPTION 2

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 4 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78204-02 MAX AVE WALL TEMP = 1237.92 AT STAGE 10
HEAT ADDITION = 4.7729+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.2008+00	0.2778	9.59446+03
EXIT	16.834	15.943	500.0	2.8231+00	0.5060	7.88038+04
IN-EX	6.6160+00		-409.00			
RATIO	0.71787		1.7423	PSEX/PTIN = 0.67986		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	9.0057-01	22.549(AFTER)
EXIT	7.5000-01	2.1173+00	18.951(BEFORE)

CASE 4 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.30	0.	132.5	1084.4	0.3060	1.12131+05
2	22.03	0.	173.8	1087.6	0.3224	1.06657+05
3	21.74	0.	215.1	1096.1	0.3396	1.01797+05
4	21.43	0.	256.2	1108.9	0.3577	9.74547+04
5	21.09	0.	297.2	1125.0	0.3770	9.35527+04
6	20.73	0.	338.1	1143.9	0.3977	9.00285+04
7	20.34	0.	378.8	1164.9	0.4202	8.68307+04
8	19.92	0.	419.3	1187.8	0.4452	8.39167+04
9	19.46	0.	459.7	1212.2	0.4734	8.12511+04
10	18.95	0.	500.0	1237.9	0.5060	7.88038+04

OPTION 2

OPTION 2

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 4 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR- LOSS	H- COEFF	F- COEFF	MASS VELOCITY
1	1.3689+00	20.90	0.		1.0640-04	4.4959-03	2.4355-01
2	1.4899+00	20.50	0.		1.1084-04	4.5411-03	2.4355-01
3	1.6171+00	20.07	0.		1.1496-04	4.5836-03	2.4355-01
4	1.7513+00	19.62	0.		1.1878-04	4.6238-03	2.4355-01
5	1.8939+00	19.13	0.		1.2235-04	4.6617-03	2.4355-01
6	2.0467+00	18.60	0.		1.2569-04	4.6977-03	2.4355-01
7	2.2121+00	18.03	0.		1.2884-04	4.7318-03	2.4355-01
8	2.3931+00	17.40	0.		1.3180-04	4.7642-03	2.4355-01
9	2.5945+00	16.71	0.		1.3460-04	4.7950-03	2.4355-01
10	2.8231+00	15.94	0.		1.3725-04	4.8245-03	2.4355-01

OPTION 3

OPTION 3

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 6 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000+00	5.0000-01	1.9635-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

OPTION 3

OPTION 3

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 6 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01   CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
2	0.2000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
8	0.8000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
9	0.9000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
10	1.0000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000

OPTION 3

OPTION 3

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 6 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

OPTION 3

OPTION 3

```
            * * * GENERAL FLOW PASSAGE (ANP 663) * * *
   INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE       6    FLOW INPUT DATA (GAS IS  AIR   ,NO  1.)
         * * * WILL EXECUTE OPTION NO  3 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.        , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=  -1.000+00, DT=    4.600-02, ET=    -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)     2.0000+03 TO     8.0000+03
    TRANSITION FOR FRICTION AT    2.3000+03

                  TOTAL           STATIC          TOTAL
                  PRESS           PRESS           TEMP
   INLET    2.34500+01                             91.00
   EXIT     0.               1.59510+01             0.
   EX/IN         0.                             0.
        PSEX/PTIN =     0.
      WEIGHT FLOW =   10.00000-03     HEAT RELEASE =     4.77150+00
      QBAR =    0.              Q/QBAR =     0.
        MAX WALL TEMP =          0.     AT STAGE NO     0


  ACCURACIES (FRACTIONAL UNLESS NOTED)
        PRESS        MACH NO     WALL TEMP(DEG)
    10.000-05    10.000-05           0.05

  COUNTER LIMITS ON ITERATIONS
       OPTION ITERATION = 15
       CHOKES/WT FLOW = 10    CHOKES/CASE = 30
       STAGE PRESS AND WALL TEMP = 40
```

OPTION 3

OPTION 3

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 6 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78052-02 MAX AVE WALL TEMP = 1237.90 AT STAGE 10
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.2000+00	0.2777	9.59142+03
EXIT	16.840	15.950	500.0	2.8203+00	0.5056	7.87781+04
IN-EX	6.6101+00		-409.01			
RATIO	0.71812		1.7423	PSEX/PTIN = 0.68016		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.9997-01	22.550(AFTER)
EXIT	7.5000-01	2.1152+00	18.955(BEFORE)

CASE 6 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.30	0.	132.5	1084.3	0.3059	1.12096+05
2	22.03	0.	173.8	1087.5	0.3223	1.06623+05
3	21.74	0.	215.1	1096.1	0.3395	1.01765+05
4	21.43	0.	256.2	1108.9	0.3576	9.74233+04
5	21.09	0.	297.2	1125.0	0.3768	9.35225+04
6	20.73	0.	338.1	1143.8	0.3975	8.99994+04
7	20.34	0.	378.8	1164.9	0.4200	8.68025+04
8	19.92	0.	419.3	1187.8	0.4449	8.38894+04
9	19.46	0.	459.8	1212.2	0.4731	8.12246+04
10	18.96	0.	500.0	1237.9	0.5056	7.87781+04

OPTION 4

```
          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
  INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE      8    FLOW INPUT DATA (GAS IS  AIR    ,NO  1.)
        * * * WILL EXECUTE OPTION NO  4 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.       , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=   -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0  TURBULENT = 0

    TRANSITION RANGE FOR N(NU)    2.0000+03 TO    8.0000+03
    TRANSITION FOR FRICTION AT   2.3000+03

                TOTAL           STATIC         TOTAL
                PRESS           PRESS          TEMP
   INLET     2.34500+01                        91.00
   EXIT      0.             1.59510+01        500.00
   EX/IN         0.                           0.
       PSEX/PTIN =    0.
     WEIGHT FLOW =  10.00000-03    HEAT RELEASE =    0.
     QBAR =   0.              Q/QBAR =    0.
       MAX WALL TEMP =          0.    AT STAGE NO    0


  ACCURACIES (FRACTIONAL UNLESS NOTED)
       PRESS        MACH NO    WALL TEMP(DEG)
    10.000-05    10.000-05             0.05

  COUNTER LIMITS ON ITERATIONS
      OPTION ITERATION = 15
      CHOKES/WT FLOW = 10   CHOKES/CASE = 30
      STAGE PRESS AND WALL TEMP = 40
```

OPTION 4

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 8 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78015-02 MAX AVE WALL TEMP = 1237.85 AT STAGE 10

HEAT ADDITION = 4.7710+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.1998+00	0.2777	9.59066+03
EXIT	16.842	15.952	500.0	2.8195+00	0.5055	7.87726+04
IN-EX	6.6085+00		-409.00			
RATIO	0.71819		1.7423	PSEX/PTIN = 0.68024		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.9982-01	22.550(AFTER)
EXIT	7.5000-01	2.1146+00	18.956(BEFORE)

OPTION 5

OPTION 5

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 10 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000+00	5.0000-01	1.9635-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

OPTION 5

OPTION 5

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 10 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
2	0.2000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
8	0.8000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
9	0.9000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
10	1.0000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000

OPTION 5

OPTION 5

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 10 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	P0	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

OPTION 5

```
            * * * GENERAL FLOW PASSAGE (ANP 663) * * *
  INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE      10     FLOW INPUT DATA (GAS IS  AIR    ,NO  1.)
        * * * WILL EXECUTE OPTION NO  5 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=   4.230+00, BL=   0.       , CL=   0.
    AT=   2.050-02, BT=   4.000-01, CT=   8.000-01
    DL=   1.600+01, EL=  -1.000+00, DT=   4.600-02, ET=   -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)    2.0000+03 TO    8.0000+03
    TRANSITION FOR FRICTION AT   2.3000+03

                TOTAL          STATIC          TOTAL
                PRESS          PRESS           TEMP
   INLET    2.34500+01                         91.00
   EXIT     1.68410+01     0.                   0.
   EX/IN       0.                              0.
       PSEX/PTIN =    0.
     WEIGHT FLOW =  10.00000-03    HEAT RELEASE =    4.77150+00
     QBAR =   0.              Q/QBAR =    0.
       MAX WALL TEMP =       0.    AT STAGE NO    0

  ACCURACIES (FRACTIONAL UNLESS NOTED)
       PRESS        MACH NO    WALL TEMP(DEG)
   10.000-05    10.000-05         0.05

  COUNTER LIMITS ON ITERATIONS
      OPTION ITERATION = 15
      CHOKES/WT FLOW = 10    CHOKES/CASE = 30
      STAGE PRESS AND WALL TEMP = 40
```

OPTION 5

OPTION 5

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 10 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78022-02 MAX AVE WALL TEMP = 1237.96 AT STAGE 10
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.1998+00	0.2777	9.59081+03
EXIT	16.841	15.951	500.0	2.8198+00	0.5056	7.87717+04
IN-EX	6.6092+00		-409.04			
RATIO	0.71816		1.7424	PSEX/PTIN = 0.68021		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.9985-01	22.550(AFTER)
EXIT	7.5000-01	2.1149+00	18.956(BEFORE)

CASE 10 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.30	0.	132.5	1084.4	0.3058	1.12088+05
2	22.03	0.	173.8	1087.6	0.3223	1.06616+05
3	21.74	0.	215.1	1096.2	0.3395	1.01757+05
4	21.43	0.	256.2	1108.9	0.3575	9.74163+04
5	21.09	0.	297.2	1125.0	0.3767	9.35155+04
6	20.73	0.	338.1	1143.9	0.3974	8.99925+04
7	20.34	0.	378.8	1164.9	0.4200	8.67958+04
8	19.92	0.	419.4	1187.8	0.4449	8.38828+04
9	19.46	0.	459.8	1212.3	0.4730	8.12181+04
10	18.96	0.	500.0	1238.0	0.5056	7.87717+04

OPTION 6

RINGS

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS CONC. RINGS

STGE	X/L	LENGTH	OUTER DIAM	INNER DIAM	RING THICK	NO RINGS
1	0.	3.0000+00	2.8530+00	3.8200-01	2.3585-02	12
2	0.	0.	0.	0.	0.	0
3	0.	0.	0.	0.	0.	0
4	0.	0.	0.	0.	0.	0
5	0.	0.	0.	0.	0.	0
6	0.	0.	0.	0.	0.	0
7	0.	0.	0.	0.	0.	0
8	0.	0.	0.	0.	0.	0
9	0.	0.	0.	0.	0.	0
10	0.	0.	0.	0.	0.	0

RINGS

RINGS

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS ELLIPTICAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
2	0.2000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
3	0.3000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
4	0.4000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
5	0.5000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
6	0.6000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
7	0.7000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
8	0.8000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
9	0.9000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000
10	1.0000	3.00000+00	1.77466-01	2.70541+00	1.0000	1.0000

RINGS

RINGS

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0.   BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

RINGS

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          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
 INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE      28    FLOW INPUT DATA (GAS IS  AIR   ,NO  1.)
       * * * WILL EXECUTE OPTION NO 11 * * *

 FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
   N(NUS)=A*(N(PR)**B)*(N(RE)**C)
   F=D*(N(RE)**E)
  NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
   AL=    4.230+00, BL=    0.        , CL=    0.
   AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
   DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=    -2.000-01

 BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
    LAMINAR = 0   TURBULENT = 0

   TRANSITION RANGE FOR N(NU)     2.0000+03 TO     8.0000+03
   TRANSITION FOR FRICTION AT    2.3000+03

                TOTAL            STATIC          TOTAL
                PRESS            PRESS           TEMP
  INLET    2.34500+01                              91.00
  EXIT     0.               0.                    500.00
  EX/IN        0.                                0.
      PSEX/PTIN =     0.
    WEIGHT FLOW =     2.50000-01     HEAT RELEASE =     4.77150+00
    QBAR =    0.               Q/QBAR =    0.
      MAX WALL TEMP =          0.     AT STAGE NO    0


 ACCURACIES (FRACTIONAL UNLESS NOTED)
      PRESS         MACH NO     WALL TEMP(DEG)
   10.000-05    10.000-05              0.05

 COUNTER LIMITS ON ITERATIONS
     OPTION ITERATION = 15
     CHOKES/WT FLOW = 10    CHOKES/CASE = 30
     STAGE PRESS AND WALL TEMP = 40
```

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 2.50000-01 MAX AVE WALL TEMP = 201.67 AT STAGE 1
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLD NO
INLET	23.450		91.0	1.6723-01	0.1013	1.29209+0
EXIT	22.305	22.254	170.2	2.0000-01	0.1134	1.41478+0
IN-EX	1.1453+00		-79.21			
RATIO	0.95116		1.1438	PSEX/PTIN = 0.94900		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	1.2542-01	23.325(AFTER)
EXIT	7.5000-01	1.5000-01	22.455(BEFORE)

CASE 28 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	23.24	0.	98.9	131.4	0.1029	1.54257+04
2	23.16	0.	106.9	139.2	0.1040	1.52698+04
3	23.08	0.	114.8	147.0	0.1052	1.51177+04
4	23.00	0.	122.7	154.8	0.1063	1.49692+04
5	22.91	0.	130.7	162.6	0.1075	1.48243+04
6	22.82	0.	138.6	170.5	0.1086	1.46827+04
7	22.73	0.	146.5	178.3	0.1098	1.45443+04
8	22.64	0.	154.4	186.1	0.1110	1.44091+04
9	22.55	0.	162.3	193.9	0.1122	1.42770+04
10	22.45	0.	170.2	201.7	0.1134	1.41478+04

RINGS

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR- LOSS	H- COEFF	F- COEFF	MASS VELOCITY
1	1.7116-01	23.07	0.		8.0367-05	6.6851-03	9.2408-02
2	1.7422-01	22.99	0.		8.0670-05	6.6987-03	9.2408-02
3	1.7731-01	22.90	0.		8.0968-05	6.7121-03	9.2408-02
4	1.8044-01	22.82	0.		8.1260-05	6.7254-03	9.2408-02
5	1.8360-01	22.73	0.		8.1547-05	6.7385-03	9.2408-02
6	1.8680-01	22.64	0.		8.1830-05	6.7514-03	9.2408-02
7	1.9004-01	22.54	0.		8.2108-05	6.7642-03	9.2408-02
8	1.9332-01	22.45	0.		8.2381-05	6.7769-03	9.2408-02
9	1.9664-01	22.35	0.		8.2650-05	6.7894-03	9.2408-02
10	2.0000-01	22.25	0.		8.2915-05	6.8017-03	9.2408-02

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 30 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS RECTANGULAR

STGE	X/L	LENGTH	WIDTH	HEIGHT
1	0.	3.0000+00	2.0000-01	2.5000-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 30 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS ROUND

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
2	0.2000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
3	0.3000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
4	0.4000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
5	0.5000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
6	0.6000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
7	0.7000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
8	0.8000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
9	0.9000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
10	1.0000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 30 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	P0	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

RECTANGULAR

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RECTANGULAR


              * * * GENERAL FLOW PASSAGE (ANP 663) * * *
   INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE      30     FLOW INPUT DATA (GAS IS  AIR    ,NO  1.)
          * * * WILL EXECUTE OPTION NO 11 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.        , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=    -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)     2.0000+03 TO     8.0000+03
    TRANSITION FOR FRICTION AT    2.3000+03

                 TOTAL            STATIC          TOTAL
                 PRESS            PRESS           TEMP
   INLET     2.34500+01                            91.00
   EXIT      0.               0.                  500.00
   EX/IN        0.                               0.
       PSEX/PTIN =     0.
     WEIGHT FLOW =    10.00000-03     HEAT RELEASE =     4.77150+00
     QBAR =    0.              Q/QBAR =     0.
       MAX WALL TEMP =          0.    AT STAGE NO     0


  ACCURACIES (FRACTIONAL UNLESS NOTED)
       PRESS        MACH NO     WALL TEMP(DEG)
    10.000-05    10.000-05             0.05

  COUNTER LIMITS ON ITERATIONS
      OPTION ITERATION = 15
      CHOKES/WT FLOW = 10    CHOKES/CASE = 30
      STAGE PRESS AND WALL TEMP = 40


* * * * *
* CALCULATION TERMINATED BY TYPE  160 ERROR AT LOC   1 * * *
* * * * *


RECTANGULAR
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RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

* * * * * * * * * * * * * * * * * * * *
* CHOKE OCURRED IN STAGE 6. IGNORE *
* ALL RESULTS THERE AND DOWNSTREAM. *
* * * * * * * * * * * * * * * * * * * *

CASE 30 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 10.00000-03 MAX AVE WALL TEMP = 2878.05 AT STAGE 10
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	7.9912-01	0.2245	3.50175+03
EXIT	22.305	22.254	1911.3	2.0000-01	0.1134	1.63399+04
IN-EX	1.1453+00		-1820.31			
RATIO	0.95116		4.3037	PSEX/PTIN = 0.94900		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	5.9934-01	22.851(AFTER)
EXIT	7.5000-01	1.5000-01	22.455(BEFORE)

CASE 30 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.22	0.	288.2	1875.9	0.2815	3.73517+04
2	21.44	0.	482.4	1876.3	0.3349	3.09774+04
3	20.46	0.	672.9	1945.8	0.3964	2.68618+04
4	19.21	0.	859.7	2049.3	0.4758	2.39958+04
5	17.52	0.	1042.7	2170.9	0.6031	2.18890+04
6	15.59	0.	1222.3	2302.4	1.0159	2.02744+04
7	22.73	0.	1398.6	2439.1	0.1098	1.89951+04
8	22.64	0.	1571.9	2583.0	0.1110	1.79526+04
9	22.55	0.	1742.7	2729.7	0.1122	1.70823+04
10	22.45	0.	1911.3	2878.1	0.1134	1.63399+04

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 30 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR- LOSS	H- COEFF	F- COEFF	MASS VELOCITY
1	1.1615+00	21.04	0.		1.1131-04	5.6014-03	2.0000-01
2	1.5412+00	19.85	0.		1.2678-04	5.8150-03	2.0000-01
3	1.9846+00	18.39	0.		1.3883-04	5.9832-03	2.0000-01
4	2.5454+00	16.52	0.		1.4855-04	6.1197-03	2.0000-01
5	3.3927+00	13.81	0.		1.5665-04	6.2332-03	2.0000-01
6	1.8680-01	8.24	0.		1.6361-04	6.3295-03	2.0000-01
7	1.9004-01	22.55	0.		1.6984-04	0.	2.0000-01
8	1.9332-01	22.46	0.		1.7479-04	0.	2.0000-01
9	1.9664-01	22.36	0.		1.7905-04	0.	2.0000-01
10	2.0000-01	22.27	0.		1.8280-04	0.	2.0000-01

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE   32   ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH =   0.   CROSS SECTION IS RECTANGULAR

STGE	X/L	LENGTH	WIDTH	HEIGHT
1	0.	3.0000+00	2.0000-01	2.5000-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 32 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS ROUND

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
2	0.2000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
3	0.3000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
4	0.4000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
5	0.5000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
6	0.6000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
7	0.7000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
8	0.8000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
9	0.9000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000
10	1.0000	3.00000+00	2.22222-01	5.00000-02	1.0000	1.0000

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 32 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0.   BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	P0	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

RECTANGULAR

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          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
  INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE     32    FLOW INPUT DATA (GAS IS  AIR   ,NO  1.)
        * * * WILL EXECUTE OPTION NO 11 * * *

 FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
   N(NUS)=A*(N(PR)**B)*(N(RE)**C)
   F=D*(N(RE)**E)
  NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
   AL=    4.230+00, BL=    0.       , CL=    0.
   AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
   DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=   -2.000-01

 BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
    LAMINAR = 0  TURBULENT = 0

   TRANSITION RANGE FOR N(NU)    2.0000+03 TO    8.0000+03
   TRANSITION FOR FRICTION AT   2.3000+03

              TOTAL          STATIC         TOTAL
              PRESS          PRESS          TEMP
  INLET    2.34500+01                        91.00
  EXIT     0.             0.                500.00
  EX/IN       0.                            0.
      PSEX/PTIN =    0.
    WEIGHT FLOW =    5.00000-03    HEAT RELEASE =    4.77150+00
    QBAR =    0.             Q/QBAR =    0.
      MAX WALL TEMP =        0.    AT STAGE NO    0


 ACCURACIES (FRACTIONAL UNLESS NOTED)
      PRESS        MACH NO    WALL TEMP(DEG)
   10.000-05    10.000-05          0.05

 COUNTER LIMITS ON ITERATIONS
     OPTION ITERATION = 15
     CHOKES/WT FLOW = 10    CHOKES/CASE = 30
     STAGE PRESS AND WALL TEMP = 40
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RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 32 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 5.00000-03 MAX AVE WALL TEMP = 3617.09 AT STAGE 5
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.9601-01	0.1097	1.75088+03
EXIT	15.719	15.070	3531.6	2.1258+00	0.4645	7.13752+03
IN-EX	7.7314+00		-3440.58			
RATIO	0.67030		7.2442	PSEX/PTIN = 0.64263		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	1.4701-01	23.303(AFTER)
EXIT	7.5000-01	1.5943+00	17.313(BEFORE)

CASE 32 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	23.06	0.	482.4	3247.3	0.1476	1.69098+04
2	22.76	0.	859.7	3157.8	0.1795	1.26660+04
3	22.40	0.	1222.3	3280.8	0.2089	1.05217+04
4	21.97	0.	1571.9	3455.3	0.2370	9.22771+03
5	21.46	0.	1911.3	3617.1	0.2651	8.35045+03
6	20.86	0.	2243.1	1842.4	0.2945	7.70127+03
7	20.17	0.	2569.6	1979.1	0.3266	7.18544+03
8	19.37	0.	2892.6	2123.0	0.3630	7.13752+03
9	18.43	0.	3213.2	2269.7	0.4070	7.13752+03
10	17.31	0.	3531.6	2418.1	0.4645	7.13752+03

RECTANGULAR

RECTANGULAR

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 32 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR- LOSS	H- COEFF	F- COEFF	MASS VELOCITY
1	3.4251-01	22.72	0.		6.3915-05	6.5634-03	10.0000-02
2	4.8849-01	22.27	0.		7.6898-05	6.9539-03	10.0000-02
3	6.3641-01	21.76	0.		8.5847-05	7.2167-03	10.0000-02
4	7.8874-01	21.17	0.		9.3831-05	7.4086-03	10.0000-02
5	9.4890-01	20.49	0.		1.0360-04	7.5582-03	10.0000-02
6	1.1215+00	19.72	0.		0.	7.6815-03	10.0000-02
7	1.3130+00	18.82	0.		0.	7.7887-03	10.0000-02
8	1.5319+00	17.79	0.		0.	7.7992-03	10.0000-02
9	1.7933+00	16.56	0.		0.	7.7992-03	10.0000-02
10	2.1258+00	15.07	0.		0.	7.7992-03	10.0000-02

ELLIPTICAL

ELLIPTICAL

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE   34   ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH =   0.   CROSS SECTION IS ELLIPTICAL

STGE	X/L	LENGTH	MAJOR AXIS	MINOR AXIS
1	0.	3.0000+00	6.0000-01	4.0000-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

ELLIPTICAL

ELLIPTICAL

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 34 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS RECTANGULAR

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
2	0.2000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
3	0.3000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
4	0.4000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
5	0.5000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
6	0.6000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
7	0.7000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
8	0.8000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
9	0.9000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000
10	1.0000	3.00000+00	4.70679-01	1.88496-01	1.0000	1.0000

ELLIPTICAL

ELLIPTICAL

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 34 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

ELLIPTICAL

ELLIPTICAL

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           * * * GENERAL FLOW PASSAGE (ANP 663) * * *
   INPUT UNITS ARE    INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE      34    FLOW INPUT DATA (GAS IS   AIR    ,NO  1.)
         * * * WILL EXECUTE OPTION NO 11 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.        , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=   -1.000+00, DT=    4.600-02, ET=    -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)    2.4760+03 TO    8.0000+03
    TRANSITION FOR FRICTION AT    2.3000+03

                TOTAL            STATIC          TOTAL
                PRESS            PRESS           TEMP
   INLET     2.34500+01                           91.00
   EXIT      0.                  0.              500.00
   EX/IN         0.                              0.
        PSEX/PTIN =     0.
      WEIGHT FLOW =     4.78042-02     HEAT RELEASE =     4.77150+00
      QBAR =    0.              Q/QBAR =    0.
        MAX WALL TEMP =         0.    AT STAGE NO    0


  ACCURACIES (FRACTIONAL UNLESS NOTED)
        PRESS        MACH NO     WALL TEMP(DEG)
    10.000-05    10.000-05          0.05

  COUNTER LIMITS ON ITERATIONS
       OPTION ITERATION = 15
       CHOKES/WT FLOW = 10    CHOKES/CASE = 30
       STAGE PRESS AND WALL TEMP = 40
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ELLIPTICAL

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 34 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78042-02 MAX AVE WALL TEMP = 1184.02 AT STAGE 1(
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.3067+00	0.2905	9.40496+0:
EXIT	15.685	14.579	500.0	3.3044+00	0.5725	7.72461+04
IN-EX	7.7653+00		-409.02			
RATIO	0.66886		1.7423	PSEX/PTIN = 0.62169		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	9.7999-01	22.470(AFTER)
EXIT	7.5000-01	2.4783+00	18.163(BEFORE)

CASE 34 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.18	0.	132.5	1006.4	0.3222	1.09916+05
2	21.87	0.	173.8	1014.2	0.3406	1.04550+05
3	21.54	0.	215.1	1026.6	0.3600	9.97860+04
4	21.17	0.	256.2	1042.6	0.3807	9.55291+04
5	20.78	0.	297.2	1061.5	0.4032	9.17041+04
6	20.35	0.	338.1	1082.7	0.4279	8.82494+04
7	19.89	0.	378.8	1105.9	0.4557	8.51147+04
8	19.37	0.	419.4	1130.7	0.4875	8.22582+04
9	18.80	0.	459.8	1156.8	0.5253	7.96451+04
10	18.16	0.	500.0	1184.0	0.5725	7.72461+04

ELLIPTICAL

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 34 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR-LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	1.4996+00	20.64	0.		1.1361-04	4.5138-03	2.5361-01
2	1.6368+00	20.19	0.		1.1815-04	4.5592-03	2.5361-01
3	1.7823+00	19.69	0.		1.2236-04	4.6020-03	2.5361-01
4	1.9377+00	19.16	0.		1.2626-04	4.6423-03	2.5361-01
5	2.1053+00	18.59	0.		1.2991-04	4.6804-03	2.5361-01
6	2.2881+00	17.96	0.		1.3333-04	4.7165-03	2.5361-01
7	2.4905+00	17.26	0.		1.3654-04	4.7507-03	2.5361-01
8	2.7190+00	16.49	0.		1.3957-04	4.7832-03	2.5361-01
9	2.9840+00	15.61	0.		1.4244-04	4.8142-03	2.5361-01
10	3.3044+00	14.58	0.		1.4516-04	4.8438-03	2.5361-01

INTERSTAGE LOSSES

INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 36 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS ROUND

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000+00	5.0000-01	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

INTERSTAGE LOSSES

INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE   36   PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH =   3.0000+01   CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H- MULT	F- MULT
1	0.1000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
2	0.2000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
8	0.8000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
9	0.9000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
10	1.0000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000

INTERSTAGE LOSSES

INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 36 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.5000	1.0000	0.2000	1.0000	0.	0.	0.
3	0.5000	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.7500	1.0000	0.7000	1.0000	0.	0.	0.
8	0.7500	1.0000	0.8000	1.0000	0.	0.	0.
9	0.7500	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

INTERSTAGE LOSSES

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INTERSTAGE LOSSES


          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
   INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

 CASE     36    FLOW INPUT DATA (GAS IS  AIR   ,NO  1.)
        * * * WILL EXECUTE OPTION NO 11 * * *

  FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
    N(NUS)=A*(N(PR)**B)*(N(RE)**C)
    F=D*(N(RE)**E)
   NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
    AL=    4.230+00, BL=    0.        , CL=    0.
    AT=    2.050-02, BT=    4.000-01, CT=    8.000-01
    DL=    1.600+01, EL=  -1.000+00, DT=    4.600-02, ET=    -2.000-01

  BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
     LAMINAR = 0   TURBULENT = 0

    TRANSITION RANGE FOR N(NU)    2.4760+03 TO    8.0000+03
    TRANSITION FOR FRICTION AT    2.3000+03

                 TOTAL            STATIC          TOTAL
                 PRESS            PRESS           TEMP
   INLET     2.34500+01                            91.00
   EXIT      0.               0.                  500.00
   EX/IN         0.                              0.
        PSEX/PTIN =     0.
      WEIGHT FLOW =     3.00000-02     HEAT RELEASE =     4.77150+00
      QBAR =    0.              Q/QBAR =    0.
        MAX WALL TEMP =          0.    AT STAGE NO    0


  ACCURACIES (FRACTIONAL UNLESS NOTED)
        PRESS        MACH NO    WALL TEMP(DEG)
    10.000-05    10.000-05          0.05

  COUNTER LIMITS ON ITERATIONS
       OPTION ITERATION = 15
       CHOKES/WT FLOW = 10    CHOKES/CASE = 30
       STAGE PRESS AND WALL TEMP = 40
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INTERSTAGE LOSSES

INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 36 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 3.00000-02 MAX AVE WALL TEMP = 1770.09 AT STAGE 10
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	4.6137-01	0.1693	6.01906+03
EXIT	17.372	17.000	735.6	1.3332+00	0.3385	4.27016+04
IN-EX	6.0780+00		-644.59			
RATIO	0.74081		2.1699	PSEX/PTIN = 0.72495		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	3.4603-01	23.104(AFTER)
EXIT	7.5000-01	9.9987-01	18.372(BEFORE)

CASE 36 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.99	0.	157.0	1685.7	0.1834	6.92835+04
2	22.86	0.29460	222.8	1644.0	0.1947	6.41813+04
3	22.43	0.32999	288.2	1625.2	0.2086	5.99230+04
4	21.95	0.	353.3	1622.3	0.2233	5.63182+04
5	21.78	0.	418.0	1631.0	0.2347	5.32294+04
6	21.61	0.	482.4	1648.3	0.2462	5.05549+04
7	21.43	0.70458	546.3	1672.1	0.2578	4.82180+04
8	20.52	0.78674	609.8	1701.1	0.2799	4.61593+04
9	19.51	0.88305	672.9	1734.0	0.3061	4.43328+04
10	18.37	0.	735.6	1770.1	0.3385	4.27016+04

INTERSTAGE LOSSES

INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 36 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR-LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	5.2841-01	22.45	0.		6.6238-05	4.9503-03	1.5279-01
2	5.8921-01	22.26	0.		7.1243-05	5.0266-03	1.5279-01
3	6.5997-01	21.76	0.		7.5736-05	5.0961-03	1.5279-01
4	7.3540-01	21.20	0.		7.9794-05	5.1597-03	1.5279-01
5	8.0185-01	20.97	0.		8.3479-05	5.2183-03	1.5279-01
6	8.6980-01	20.73	0.		8.6846-05	5.2724-03	1.5279-01
7	9.3944-01	20.48	0.		8.9937-05	5.3225-03	1.5279-01
8	1.0490+00	19.45	0.		9.2787-05	5.3692-03	1.5279-01
9	1.1774+00	18.31	0.		9.5425-05	5.4127-03	1.5279-01
10	1.3332+00	17.00	0.		9.7877-05	5.4534-03	1.5279-01

AUTO INTERSTAGE LOSSES

AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 38 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS ROUND

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000+00	4.0000-01	0.
2	0.	0.	0.	0.
3	0.	0.	5.0000-01	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	4.0000-01	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

AUTO INTERSTAGE LOSSES

AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 38 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H-MULT	F-MULT
1	0.1000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
2	0.2000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
8	0.8000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
9	0.9000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
10	1.0000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000

AUTO INTERSTAGE LOSSES

AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 38 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 1.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	PO	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.5000	1.0000	0.2000	1.0000	0.	0.	0.
3	0.5000	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.7500	1.0000	0.7000	1.0000	0.	0.	0.
8	0.7500	1.0000	0.8000	1.0000	0.	0.	0.
9	0.7500	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

AUTO INTERSTAGE LOSSES

AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 38 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 3.00000-02 MAX AVE WALL TEMP = 1648.26 AT STAGE 6
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.1519+00	0.2718	7.52382+03
EXIT	14.283	12.766	735.6	4.0753+00	0.6829	5.33770+04
IN-EX	9.1667+00		-644.59			
RATIO	0.60909		2.1699	PSEX/PTIN = 0.54438		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.6390-01	22.586(AFTER)
EXIT	7.5000-01	3.0565+00	17.340(BEFORE)

CASE 38 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.24	0.	157.0	1344.6	0.3071	8.66043+04
2	21.85	0.20211	222.8	1336.0	0.3321	8.02266+04
3	21.50	0.	288.2	1625.2	0.2181	5.99230+04
4	21.35	0.	353.3	1622.3	0.2300	5.63182+04
5	21.18	0.	418.0	1631.0	0.2419	5.32294+04
6	21.01	0.43397	482.4	1648.3	0.2539	5.05549+04
7	19.94	0.	546.3	1449.9	0.4747	6.02725+04
8	19.22	0.	609.8	1488.2	0.5223	5.76992+04
9	18.37	0.	672.9	1529.1	0.5853	5.54160+04
10	17.34	0.	735.6	1572.2	0.6829	5.33770+04

AUTO INTERSTAGE LOSSES

AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 38 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO INTR-STG LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	1.3740+00	20.83	0.	1.0658-04	4.7342-03	2.3873-01
2	1.5595+00	20.25	0.12960	1.1369-04	4.8072-03	2.3873-01
3	6.8964-01	20.81	0.	7.5736-05	5.0961-03	1.5279-01
4	7.5708-01	20.58	0.	7.9794-05	5.1597-03	1.5279-01
5	8.2602-01	20.34	0.	8.3479-05	5.2183-03	1.5279-01
6	8.9665-01	20.09	0.48399	8.6846-05	5.2724-03	1.5279-01
7	2.6633+00	17.12	0.	1.4007-04	5.0902-03	2.3873-01
8	3.0052+00	16.00	0.	1.4409-04	5.1348-03	2.3873-01
9	3.4400+00	14.63	0.	1.4782-04	5.1764-03	2.3873-01
10	4.0753+00	12.77	0.	1.5129-04	5.2154-03	2.3873-01

MODIFIED AUTO INTERSTAGE LOSSES

MODIFIED AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 40 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 1.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	P0	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.5000	0.7500	0.2000	1.0000	0.	0.	0.
3	0.5000	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	0.7500	0.6000	1.0000	0.	0.	0.
7	0.7500	1.0000	0.7000	1.0000	0.	0.	0.
8	0.7500	1.0000	0.8000	1.0000	0.	0.	0.
9	0.7500	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

MODIFIED AUTO INTERSTAGE LOSSES

MODIFIED AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 40 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 3.00000-02 MAX AVE WALL TEMP = 1648.26 AT STAGE 6
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.1519+00	0.2718	7.52382+03
EXIT	14.588	13.133	735.6	3.9774+00	0.6651	5.33770+04
IN-EX	8.8616+00		-644.59			
RATIO	0.62211		2.1699	PSEX/PTIN = 0.56006		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.6390-01	22.586(AFTER)
EXIT	7.5000-01	2.9830+00	17.571(BEFORE)

CASE 40 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.24	0.	157.0	1344.6	0.3071	8.66043+04
2	21.85	0.15158	222.8	1336.0	0.3321	8.02266+04
3	21.56	0.	288.2	1625.2	0.2175	5.99230+04
4	21.40	0.	353.3	1622.3	0.2294	5.63182+04
5	21.23	0.	418.0	1631.0	0.2413	5.32294+04
6	21.06	0.32462	482.4	1648.3	0.2532	5.05549+04
7	20.11	0.	546.3	1449.9	0.4693	6.02725+04
8	19.40	0.	609.8	1488.2	0.5153	5.76992+04
9	18.57	0.	672.9	1529.1	0.5753	5.54160+04
10	17.57	0.	735.6	1572.2	0.6651	5.33770+04

MODIFIED AUTO INTERSTAGE LOSSES

MODIFIED AUTO INTERSTAGE LOSSES

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 40 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO INTR-STG LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	1.3740+00	20.83	0.	1.0658-04	4.7342-03	2.3873-01
2	1.5595+00	20.25	0.12960	1.1369-04	4.8072-03	2.3873-01
3	6.8793-01	20.86	0.	7.5736-05	5.0961-03	1.5279-01
4	7.5516-01	20.64	0.	7.9794-05	5.1597-03	1.5279-01
5	8.2388-01	20.40	0.	8.3479-05	5.2183-03	1.5279-01
6	8.9428-01	20.15	0.48399	8.6846-05	5.2724-03	1.5279-01
7	2.6344+00	17.33	0.	1.4007-04	5.0902-03	2.3873-01
8	2.9668+00	16.23	0.	1.4409-04	5.1348-03	2.3873-01
9	3.3846+00	14.90	0.	1.4782-04	5.1764-03	2.3873-01
10	3.9774+00	13.13	0.	1.5129-04	5.2154-03	2.3873-01

X/L STAGE LENGTH INPUT

X/L STAGE LENGTH INPUT

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 42   ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 3.0000+01   CROSS SECTION IS ROUND

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.1000	0.	4.0000-01	0.
2	0.2000	0.	0.	0.
3	0.3000	0.	5.0000-01	0.
4	0.4000	0.	0.	0.
5	0.5000	0.	0.	0.
6	0.6000	0.	0.	0.
7	0.7000	0.	4.0000-01	0.
8	0.8000	0.	0.	0.
9	0.9000	0.	0.	0.
10	1.0000	0.	0.	0.

X/L STAGE LENGTH INPUT

X/L STAGE LENGTH INPUT

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 42 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000+01 CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H-MULT	F-MULT
1	0.1000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
2	0.2000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
3	0.3000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
4	0.4000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
5	0.5000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
6	0.6000	3.00000+00	5.00000-01	1.96350-01	1.0000	1.0000
7	0.7000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
8	0.8000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
9	0.9000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000
10	1.0000	3.00000+00	4.00000-01	1.25664-01	1.0000	1.0000

X/L STAGE LENGTH INPUT

X/L STAGE LENGTH INPUT

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 42 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 3.00000-02 MAX AVE WALL TEMP = 1648.26 AT STAGE 6
HEAT ADDITION = 4.7715+00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.1519+00	0.2718	7.52382+03
EXIT	14.588	13.133	735.6	3.9774+00	0.6651	5.33770+04
IN-EX	8.8616+00		-644.59			
RATIO	0.62211		2.1699	PSEX/PTIN = 0.56006		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000-01	8.6390-01	22.586(AFTER)
EXIT	7.5000-01	2.9830+00	17.571(BEFORE)

CASE 42 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.24	0.	157.0	1344.6	0.3071	8.66043+04
2	21.85	0.15158	222.8	1336.0	0.3321	8.02266+04
3	21.56	0.	288.2	1625.2	0.2175	5.99230+04
4	21.40	0.	353.3	1622.3	0.2294	5.63182+04
5	21.23	0.	418.0	1631.0	0.2413	5.32294+04
6	21.06	0.32462	482.4	1648.3	0.2532	5.05549+04
7	20.11	0.	546.3	1449.9	0.4693	6.02725+04
8	19.40	0.	609.8	1488.2	0.5153	5.76992+04
9	18.57	0.	672.9	1529.1	0.5753	5.54160+04
10	17.57	0.	735.6	1572.2	0.6651	5.33770+04

X/L STAGE LENGTH INPUT

X/L STAGE LENGTH INPUT

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 42 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO INTR-STG LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	1.3740+00	20.83	0.	1.0658-04	4.7342-03	2.3873-01
2	1.5595+00	20.25	0.12960	1.1369-04	4.8072-03	2.3873-01
3	6.8793-01	20.86	0.	7.5736-05	5.0961-03	1.5279-01
4	7.5516-01	20.64	0.	7.9794-05	5.1597-03	1.5279-01
5	8.2388-01	20.40	0.	8.3479-05	5.2183-03	1.5279-01
6	8.9428-01	20.15	0.48399	8.6846-05	5.2724-03	1.5279-01
7	2.6344+00	17.33	0.	1.4007-04	5.0902-03	2.3873-01
8	2.9668+00	16.23	0.	1.4409-04	5.1348-03	2.3873-01
9	3.3846+00	14.90	0.	1.4782-04	5.1764-03	2.3873-01
10	3.9774+00	13.13	0.	1.5129-04	5.2154-03	2.3873-01

X/L STAGE LENGTH INPUT

X/L STAGE LENGTH INPUT

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

SUMMARY PRINTOUT FOR 20 POINTS (GAS IS AIR , NO 1)
(CASES 2 THRU 42)

CASE	WEIGHT FLOW	INLET P-TOT	EXIT P-TOT	PTEX/ PTIN	EXIT P-STAT	PSEX/ PTIN
2	4.78042-02	23.450	16.840	0.71813	15.950	0.68018
4	4.78204-02	23.450	16.834	0.71787	15.943	0.67986
6	4.78052-02	23.450	16.840	0.71812	15.950	0.68016
8	4.78015-02	23.450	16.842	0.71819	15.952	0.68024
10	4.78022-02	23.450	16.841	0.71816	15.951	0.68021
12	4.78020-02	23.450	16.841	0.71818	15.951	0.68023
14	4.78063-02	23.451	16.841	0.71814	15.951	0.68019
16	4.78063-02	23.451	16.841	0.71814	15.951	0.68019
18	4.78063-02	23.451	16.841	0.71814	15.951	0.68018
20	4.78063-02	23.451	16.841	0.71814	15.951	0.68019
22	4.78063-02	23.450	16.840	0.71811	15.949	0.68015
24	4.78063-02	23.450	16.840	0.71811	15.949	0.68015
26	4.78068-02	23.450	16.839	0.71810	15.949	0.68014
28	2.50000-01	23.450	22.305	0.95116	22.254	0.94900
32	5.00000-03	23.450	15.719	0.67030	15.070	0.64263
34	4.78042-02	23.450	15.685	0.66886	14.579	0.62169
36	3.00000-02	23.450	17.372	0.74081	17.000	0.72495
38	3.00000-02	23.450	14.283	0.60909	12.766	0.54438
40	3.00000-02	23.450	14.588	0.62211	13.133	0.56006
42	3.00000-02	23.450	14.588	0.62211	13.133	0.56006

X/L STAGE LENGTH INPUT

X/L STAGE LENGTH INPUT

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

SUMMARY PRINTOUT FOR 20 POINTS (GAS IS AIR , NO 1)
(CASES 2 THRU 42)

CASE	INLET T-TOT	EXIT T-TOT	TTEX/ TTIN	HEAT ADDITION	MAX AVE SURF-TEMP	AT STGE
2	91.0	500.0	1.74233	4.77150+00	1237.9	10
4	91.0	500.0	1.74229	4.77286+00	1237.9	10
6	91.0	500.0	1.74231	4.77150+00	1237.9	10
8	91.0	500.0	1.74229	4.77097+00	1237.9	10
10	91.0	500.0	1.74236	4.77150+00	1238.0	10
12	91.0	500.0	1.74229	4.77102+00	1237.9	10
14	91.0	500.0	1.74229	4.77150+00	1237.9	10
16	91.0	500.0	1.74229	4.77145+00	1237.9	10
18	91.0	500.0	1.74229	4.77150+00	1237.9	10
20	91.0	500.0	1.74229	4.77145+00	1237.9	10
22	91.0	500.0	1.74229	4.77150+00	1237.9	10
24	91.0	500.0	1.74229	4.77145+00	1237.9	10
26	91.0	500.0	1.74229	4.77150+00	1237.9	10
28	91.0	170.2	1.14376	4.77150+00	201.7	10
32	91.0	3531.6	7.24424	4.77150+00	3617.1	5
34	91.0	500.0	1.74233	4.77150+00	1184.0	10
36	91.0	735.6	2.16985	4.77150+00	1770.1	10
38	91.0	735.6	2.16985	4.77150+00	1648.3	6
40	91.0	735.6	2.16985	4.77150+00	1648.3	6
42	91.0	735.6	2.16985	4.77150+00	1648.3	6

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 13 ORIGINAL GEOMETRICAL INPUT DATA

TOTAL LENGTH = 0. CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA
1	0.	3.0000E 00	5.0000E-01	1.9635E-01
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	C.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 13 PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS

TOTAL LENGTH = 3.0000E 01 CROSS SECTION IS GENERAL

STGE	X/L	LENGTH	HYDR. DIAM	FLOW AREA	H-MULT	F-MULT
1	0.1000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
2	0.2000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
3	0.3000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
4	0.4000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
5	0.5000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
6	0.6000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
7	0.7000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
8	0.8000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
9	0.9000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000
10	1.0000	3.00000E 00	5.00000E-01	1.96350E-01	1.0000	1.0000

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 13 POWER PROFILE AND INTERSTAGE LOSS INPUT

AUTOLOSS CALC = 0.
INTENDED ENTRANCE LENGTH EFFECT = 0.
BETA1 = 0. BETA2 = 0.

STGE	INTRSTGE LOSS COF	AUTO LOSS MULT	PHISUM	PHIEX	P0	P1	P2
1	0.	1.0000	0.1000	1.0000	0.	0.	0.
2	0.	1.0000	0.2000	1.0000	0.	0.	0.
3	0.	1.0000	0.3000	1.0000	0.	0.	0.
4	0.	1.0000	0.4000	1.0000	0.	0.	0.
5	0.	1.0000	0.5000	1.0000	0.	0.	0.
6	0.	1.0000	0.6000	1.0000	0.	0.	0.
7	0.	1.0000	0.7000	1.0000	0.	0.	0.
8	0.	1.0000	0.8000	1.0000	0.	0.	0.
9	0.	1.0000	0.9000	1.0000	0.	0.	0.
10	0.	1.0000	1.0000	1.0000	0.	0.	0.

PARAMETRIC

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          * * * GENERAL FLOW PASSAGE (ANP 663) * * *
 INPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE      13     FLOW INPUT DATA (GAS IS  AIR    ,NO  1.)
        * * * WILL EXECUTE OPTION NO 12 * * *

 FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
   N(NUS)=A*(N(PR)**B)*(N(RE)**C)
   F=D*(N(RE)**E)
  NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
   AL=  4.230E 00, BL=  0.         , CL=  0.
   AT=  2.050E-02, BT=  4.000E-01, CT=  8.000E-01
   DL=  1.600E 01, EL= -1.000E 00, DT=  4.600E-02, ET=  -2.000E-01

 BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
    LAMINAR = 0   TURBULENT = 0

   TRANSITION RANGE FOR N(NU)   2.0000E 03 TO   8.0000E 03
   TRANSITION FOR FRICTION AT  2.3000E 03

                 TOTAL          STATIC         TOTAL
                 PRESS          PRESS          TEMP
  INLET   2.34500E 01                            91.00
  EXIT    0.            0.                      500.00
  EX/IN        0.                               0.
      PSEX/PTIN =    0.
    WEIGHT FLOW =  4.78063E-02     HEAT RELEASE =   0.
    QBAR =   0.               Q/QBAR =   0.
      MAX WALL TEMP =        0.    AT STAGE NO    0

 ACCURACIES (FRACTIONAL UNLESS NOTED)
      PRESS        MACH NO    WALL TEMP(DEG)
  10.000E-05   10.000E-05          0.05

 COUNTER LIMITS ON ITERATIONS
     OPTION ITERATION = 15
     CHOKES/WT FLOW = 10    CHOKES/CASE = 30
     STAGE PRESS AND WALL TEMP = 40
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PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

INPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 13 PARAMETRIC SETUP (16 CASES)

	INLET TOT PRESS	INLET TEMP	EXIT ~~MAX AVE~~ ~~SURF~~ TEMP	MAX AVE ~~HEAT RELEASE~~ SURF TEMP
INCREMENT	5.0000E 00	1.0000E 02	1.0000E 02	0.
NO OF TIMES	2	2	2	0

	EXIT STAT PRESS	EXIT TOT PRESS	WEIGHT FLOW	HEAT RELEASE ~~EXIT TEMP~~
INCREMENT	0.	0.	-10.0000E-03	0.
NO OF TIMES	0	0	2	0

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 13 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78063E-02 MAX AVE WALL TEMP = 1237.87 AT STAGE 10
HEAT ADDITION = 4.7715E 00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.2000E 00	0.2777	9.59163E 03
EXIT	16.840	15.949	500.0	2.8204E 00	0.5057	7.87805E 04
IN-EX	6.6104E 00		-409.00			
RATIO	0.71811		1.7423	PSEX/PTIN = 0.68015		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000E-01	9.0001E-01	22.550(AFTER)
EXIT	7.5000E-01	2.1153E 00	18.955(BEFORE)

CASE 13 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.30	0.	132.5	1084.3	0.3059	1.12098E 05
2	22.03	0.	173.8	1087.5	0.3223	1.06626E 05
3	21.74	0.	215.1	1096.1	0.3395	1.01767E 05
4	21.43	0.	256.2	1108.8	0.3576	9.74259E 04
5	21.09	0.	297.2	1125.0	0.3768	9.35251E 04
6	20.73	0.	338.1	1143.8	0.3975	9.00019E 04
7	20.34	0.	378.8	1164.9	0.4200	8.68051E 04
8	19.92	0.	419.3	1187.7	0.4449	8.38920E 04
9	19.46	0.	459.7	1212.2	0.4731	8.12271E 04
10	18.95	0.	500.0	1237.9	0.5057	7.87805E 04

PARAMETRIC

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE   INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 13 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR- LOSS	H- COEFF	F- COEFF	MASS VELOCITY
1	1.3680E 00	20.90	0.		1.0638E-04	4.4961E-03	2.4347E-01
2	1.4889E 00	20.50	0.		1.1082E-04	4.5414E-03	2.4347E-01
3	1.6159E 00	20.08	0.		1.1493E-04	4.5839E-03	2.4347E-01
4	1.7500E 00	19.62	0.		1.1875E-04	4.6241E-03	2.4347E-01
5	1.8925E 00	19.13	0.		1.2232E-04	4.6620E-03	2.4347E-01
6	2.0452E 00	18.60	0.		1.2567E-04	4.6979E-03	2.4347E-01
7	2.2104E 00	18.03	0.		1.2881E-04	4.7320E-03	2.4347E-01
8	2.3912E 00	17.41	0.		1.3177E-04	4.7645E-03	2.4347E-01
9	2.5922E 00	16.72	0.		1.3457E-04	4.7953E-03	2.4347E-01
10	2.8204E 00	15.95	0.		1.3722E-04	4.8247E-03	2.4347E-01

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 14 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 4.78063E-02 MAX AVE WALL TEMP = 1517.38 AT STAGE 10
HEAT ADDITION = 5.9651E 00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	23.450		91.0	1.2000E 00	0.2777	9.59163E 03
EXIT	15.780	14.656	600.0	3.3458E 00	0.5757	7.37017E 04
IN-EX	7.6705E 00		-509.00			
RATIO	0.67290		1.9238	PSEX/PTIN = 0.62500		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000E-01	9.0001E-01	22.550(AFTER)
EXIT	7.5000E-01	2.5093E 00	18.289(BEFORE)

CASE 14 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	22.27	0.	142.8	1411.5	0.3093	1.11377E 05
2	21.97	0.	194.5	1394.2	0.3294	1.04737E 05
3	21.64	0.	246.0	1388.9	0.3504	9.89976E 04
4	21.29	0.	297.2	1392.5	0.3727	9.39895E 04
5	20.90	0.	348.3	1403.1	0.3968	8.95837E 04
6	20.48	0.	399.1	1419.0	0.4231	8.56794E 04
7	20.01	0.	449.7	1439.1	0.4524	8.21971E 04
8	19.50	0.	500.1	1462.6	0.4861	7.90729E 04
9	18.93	0.	550.2	1488.9	0.5260	7.62552E 04
10	18.29	0.	600.0	1517.4	0.5757	7.37017E 04

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 14 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR-LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	1.3951E 00	20.84	0.		9.9777E-05	4.5019E-03	2.4347E-01
2	1.5451E 00	20.38	0.		1.0551E-04	4.5576E-03	2.4347E-01
3	1.7037E 00	19.88	0.		1.1076E-04	4.6093E-03	2.4347E-01
4	1.8727E 00	19.35	0.		1.1557E-04	4.6574E-03	2.4347E-01
5	2.0544E 00	18.76	0.		1.2001E-04	4.7023E-03	2.4347E-01
6	2.2520E 00	18.12	0.		1.2412E-04	4.7444E-03	2.4347E-01
7	2.4703E 00	17.41	0.		1.2794E-04	4.7839E-03	2.4347E-01
8	2.7161E 00	16.62	0.		1.3151E-04	4.8212E-03	2.4347E-01
9	3.0010E 00	15.72	0.		1.3485E-04	4.8563E-03	2.4347E-01
10	3.3458E 00	14.66	0.		1.3798E-04	4.8895E-03	2.4347E-01

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 FLOW AND TEMPERATURE RESULTS (GAS IS AIR , NO 1)

WEIGHT FLOW = 3.78063E-02 MAX AVE WALL TEMP = 1275.73 AT STAGE 10

HEAT ADDITION = 3.8058E 00

	TOTAL PRESS	STATIC PRESS	TOTAL TEMP	DYNAMIC PRESS	MACH NO	REYNOLDS NO
INLET	28.450		191.0	7.1650E-01	0.1923	6.73213E 03
EXIT	25.195	24.847	600.0	1.2930E 00	0.2749	5.80994E 04
IN-EX	3.2549E 00		-409.00			
RATIO	0.88559		1.6283	PSEX/PTIN = 0.87336		

ENTRANCE AND EXIT LOSSES

	LOSS COEFF	P-TOT LOSS	TOT PRESS
INLET	7.5000E-01	5.3738E-01	27.913(AFTER)
EXIT	7.5000E-01	9.6975E-01	26.165(BEFORE)

CASE 28 STAGE-BY-STAGE OUTPUT RESULTS

STGE	EXIT P-TOT	INTRSTGE P-TO LOSS	EXIT T-TOT	EXIT T-WALL	EXIT MACH NO	AVE REYN NO
1	27.77	0.	232.6	1059.5	0.2038	7.89918E 04
2	27.63	0.	274.0	1075.8	0.2115	7.56849E 04
3	27.48	0.	315.3	1094.9	0.2191	7.27095E 04
4	27.31	0.	356.4	1116.4	0.2268	7.00188E 04
5	27.14	0.	397.4	1139.8	0.2345	6.75746E 04
6	26.97	0.	438.2	1164.7	0.2423	6.53450E 04
7	26.78	0.	478.9	1191.0	0.2502	6.33035E 04
8	26.58	0.	519.4	1218.4	0.2583	6.14277E 04
9	26.38	0.	559.8	1246.7	0.2665	5.96984E 04
10	26.16	0.	600.0	1275.7	0.2749	5.80994E 04

PARAMETRIC

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *
OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

CASE 28 MISCELLANEOUS STAGE-BY-STAGE OUTPUT

STGE	EXIT P-DYN	EXIT P-STAT	AUTO STG	INTR-LOSS	H-COEFF	F-COEFF	MASS VELOCITY
1	7.8255E-01	26.98	0.		9.7666E-05	4.8222E-03	1.9255E-01
2	8.3504E-01	26.78	0.		1.0072E-04	4.8636E-03	1.9255E-01
3	8.8838E-01	26.58	0.		1.0358E-04	4.9027E-03	1.9255E-01
4	9.4265E-01	26.36	0.		1.0626E-04	4.9399E-03	1.9255E-01
5	9.9793E-01	26.13	0.		1.0879E-04	4.9751E-03	1.9255E-01
6	1.0543E 00	25.90	0.		1.1117E-04	5.0086E-03	1.9255E-01
7	1.1119E 00	25.65	0.		1.1342E-04	5.0405E-03	1.9255E-01
8	1.1708E 00	25.39	0.		1.1555E-04	5.0709E-03	1.9255E-01
9	1.2311E 00	25.13	0.		1.1758E-04	5.0999E-03	1.9255E-01
10	1.2930E 00	24.85	0.		1.1952E-04	5.1277E-03	1.9255E-01

PARAMETRIC

PARAMETRIC

* * * GENERAL FLOW PASSAGE (ANP 663) * * *

OUTPUT UNITS ARE INCHES, SQ. IN., PSIA, DEG F, BTU/SEC, LBM/SEC.

SUMMARY PRINTOUT FOR 17 POINTS (GAS IS AIR , NO 1)
(CASES 12 THRU 28)

CASE	WEIGHT FLOW	INLET P-TOT	EXIT P-TOT	PTEX/ PTIN	EXIT P-STAT	PSEX/ PTIN
NOT PARAMETRIC → 12	4.78063E-02	23.450	16.840	0.71811	15.949	0.68015
13	4.78063E-02	23.450	16.840	0.71811	15.949	0.68015
14	4.78063E-02	23.450	15.780	0.67290	14.656	0.62500
15	3.78063E-02	23.450	19.768	0.84299	19.353	0.82528
16	3.78063E-02	23.450	19.323	0.82400	18.845	0.80364
17	4.78063E-02	23.450	16.672	0.71098	15.769	0.67244
18	4.78063E-02	23.450	15.581	0.66443	14.433	0.61549
19	3.78063E-02	23.450	19.692	0.83976	19.275	0.82196
20	3.78063E-02	23.450	19.243	0.82059	18.763	0.80012
21	4.78063E-02	28.450	23.615	0.83005	23.052	0.81025
22	4.78063E-02	28.450	23.015	0.80895	22.363	0.78606
23	3.78063E-02	28.450	25.573	0.89888	25.266	0.88807
24	3.78063E-02	28.450	25.251	0.88757	24.904	0.87537
25	4.78063E-02	28.450	23.519	0.82667	22.953	0.80677
26	4.78063E-02	28.450	22.912	0.80536	22.257	0.78233
27	3.78063E-02	28.450	25.518	0.89696	25.210	0.88612
28	3.78063E-02	28.450	25.195	0.88559	24.847	0.87336

SUMMARY PRINTOUT FOR 17 POINTS (GAS IS AIR , NO 1)
(CASES 12 THRU 28)

CASE	INLET T-TOT	EXIT T-TOT	TTEX/ TTIN	HEAT ADDITION	MAX AVE SURF-TEMP	AT STGE
NOT PARAMETRIC → 12	91.0	500.0	1.74229	4.77145E 00	1237.9	10
13	91.0	500.0	1.74229	4.77145E 00	1237.9	10
14	91.0	600.0	1.92377	5.96513E 00	1517.4	10
15	91.0	500.0	1.74229	3.77337E 00	1198.1	10
16	91.0	600.0	1.92377	4.71736E 00	1467.1	10
17	191.0	500.0	1.47465	3.61882E 00	1037.0	10
18	191.0	600.0	1.62826	4.81250E 00	1313.6	10
19	191.0	500.0	1.47465	2.86184E 00	1009.1	10
20	191.0	600.0	1.62826	3.80583E 00	1275.7	10
21	91.0	500.0	1.74229	4.77145E 00	1237.9	10
22	91.0	600.0	1.92377	5.96513E 00	1517.4	10
23	91.0	500.0	1.74229	3.77337E 00	1198.1	10
24	91.0	600.0	1.92377	4.71736E 00	1467.1	10
25	191.0	500.0	1.47465	3.61882E 00	1037.0	10
26	191.0	600.0	1.62826	4.81250E 00	1313.6	10
27	191.0	500.0	1.47465	2.86184E 00	1009.1	10
28	191.0	600.0	1.62826	3.80583E 00	1275.7	10

VII PROGRAMMER AND ANALYST COMMENTS

1. There are slight discrepancies known to exist between the GFP binary program deck filed with GE FPLD Computations Operation and the Fortran source deck listed in the present report. Shortage of time has prevented reassembly of the offending subroutines. If such occurences prove sufficiently inconvenient, it will be necessary for the user to reassemble these subroutines.

   In the existing assembly of the INPPRT subroutine which prints out input data, parametric input is mislabeled. The order of labeling, left to right and first to second line, should be INLET TOT PRESS, INLET TEMP, EXIT TEMP, MAX AVE SURF TEMP, EXIT STAT PRESS, EXIT TOT PRESS, WEIGHT FLOW, and HEAT RELEASE. In addition, the geometrical cross section is mis-named in the heading of the processed geometry printout.

   In the existing assembly of the ØUTPUT subroutine which prints out the calculation results, the inlet Reynolds Number should be multiplied by 12 and what is listed as the exit Reynolds Number is actually the average Reynolds Number for the last stage. In addition, when feet are the basic unit of output, neither the stagewise heat transfer coefficients or mass velocities have their units changed.

   As presently assembled, the DPFRLT subroutine which carries out the pressure drop computations can carry out only automatic interstage loss calculations or arbitrary interstage coefficient loss calculations, not an intermixture of the two types. This is an unreasonable situation and the source deck has been changed to permit such an intermixture.

   The DATPRØ (data processing) subroutine will not distribute the modifying coefficients (CLSMØD) for automatic interstage loss coefficients by means of the mnemonic NCLSMD. The source deck, however, has been corrected so that this distribution can be carried out if a reassembly is made.

2. Insofar as the writer knows, there are no requirements for the GFP program that cannot be carried out equally well by the IBM 704 and IBM 7090 computers. For other machines, this would presumably be dependent on the adequacy of the particular compiler which would have to operate upon the Fortran source deck. The TABLE specification which has been used many places in the GFP program may not be available for IBM 704 compilers, but standard coding methods can be used to accomplish the same purpose; it just takes more effort.

3. The LMPRØP subroutine discussed in Appendix A is rather annoying when used in an iterative program such as GFP. Although the final results of the calculations may lie well within the valid range for thermal property correlations, a monstrous number of comments could be printed out regarding the temperature limits of one or more properties because of extreme temperatures arising during the course of the iterations.

   The writer recommends that serious consideration be given to the possibility of adding an extra control in CØMMØN storage which will actually control

outputting from LMPRØP so that during iterations it will be suppressed but after convergence it will be functional. In general, this would require a repeat of the pressure drop and wall temperature calculation routines after it was established that convergence had taken place.

For the present, the writer has left (with some qualms a dummy version of LMPRØP at the beginning of the binary deck on file. This version does not print comments. It may be wise to remove it for production useage.

4. It was mentioned in the Introduction that the GFP heat transfer treatment has been tailored to nuclear heat transfer problems. In such problems, it is usually known what amount of heat is going to be released and where the release will take place. Thus, the result to be obtained is usually the surface temperature which will result in convective transfer of the specified amount of heat into a coolant stream. For this reason, it has been possible to uncouple the heat transfer calculations from those for pressure drop.

Another type of problem for which it might be desirable to adapt the GFP program would be those where a desired axial surface temperature profile is known and it is desired to compute the resultant bulk fluid temperatures and convective heat transfer rates. Under these circumstances, a different (but more tightly bounded) type of iteration would be required in which the procedure might be as follows (assuming the most difficult case of film-temperature-based heat transfer coefficient);

a) Assume film temperature to be mean of inlet bulk and specified surface temperature for the stage and calculate convective heat transfer coefficient (CHTC).

b) Calculate the enthalpy change in the fluid and its temperature change.

c) Recompute the CHTC with the new film temperature and repeat steps b) and c) until bulk temperature change is less than some convergence criteria.

One matter that needs considerable thought in formulating such a routine is the question of whether one wants an average or mean temperature for the stage or a local temperature such as the trailing edge temperature. In the former case one would ordinarily base the film temperature drop on the mean temperature for the stage and modify the calculated enthalpy rise accordingly. In the latter case, it becomes somewhat tricky to compute the total enthalpy rise while at the same time getting the necessary local heat or enthalpy rate unless some sort of trailing edge factor can be established (similar to that used in the present version of GFP).

Obviously, it is not possible to uncouple the heat transfer and pressure drop computations in an example such as has been discussed wherein the heat transfer calculation determines the bulk temperatures which are needed in computing the pressure drop.

VIII NOMENCLATURE

VIII.1 Input Variables

Math Symbol	Mnemonic	Col. 1 Control	Meaning or Function
	FTIN	4	= 0 input is in inches and derivatives; > 0 input is in feet and derivatives;
	FTØUT	4	= 0 output is in inches and derivatives; > 0 output is in feet and derivatives;
	RNKIN	4	= 0 input is in deg. F > 0 input is in deg. R
	RNKØUT	4	= 0 output is in deg. F > 0 output is in deg. R
D_h	DH_{101}	3	Hydraulic diams (offset)
A_{ff}	AFF_{101}	3	Free flow area (offset)
	$RØUND_{101}$	4	> 0 $AFF_i = \frac{\pi}{4} DH_i^2$ automatically = 0 no action
L	$LENGTH(ØLEN)_{101}$	3	Stage lengths (offset)
	$CLØSS_{101}$	3	Interstage loss coefficients (offset)
	NDH, NAFF(NAFL), NLEN, NCLØSS	4 100	Stagewise distribution controls for DH, AFF, LENGTH, and CLØSS, respectively
P_{Tin}	PTIN(PIN)	3	Inlet total pressure
T_{Tin}	TTIN(TIN)	3	Inlet total temperature
P_{Tex}	PTEX(PEX)	3	Exit total pressure
P_{Sex}	PSEX	3	Exit static pressure
W	W	3	Mass flow
T_{Wmax}	TWMAX	3	Maximum stage trailing edge temperature
Q	QTØT	3	Passage heat release
T_{Tex}	TTEX(TEX)	3	Passage exit total temperature.
β_1 β_2	BETA1 BETA2	3	Entrance length effect friction factor coefficients for laminar and for turbulent flow, respectively.
a_L a_T	COFHLM COFHTB	3	Nusselt No. coefficient for laminar and for turbulent flow, respectively.

b_L b_T	EXHPLM EXHPTB	3	Prandtl No. exponent for laminar and for turbulent flow, respectively.
c_L c_T	EXHRLM EXHRTB	3	Reynolds No. exponent for laminar and for turbulent flow, respectively.
d_L d_T	CØFFLM CØFFTB	3	Friction factor coefficient for laminar and for turbulent flow, respectively.
e_L e_T	EXPFLM EXPFTB	3	Reynolds no. exponent in friction factor correlation for laminar and for turbulent flow, respectively.
	ENTRNC	3	Calculate entrance length effects.
	GAS	3	Gas selector (1 for air, 4 for H_2, 6 for He, 9 for Ne)
	ACCMNØ	3	Fractional accuracy on Mach No. (initialized = 0.0001)
	ACCPRS	3	Fractional accuracy on pressures (initialized = 0.0001)
	ACCTMP	3	Absolute accuracy on temperatures (initialized = 0.049 deg.)
	LIMCHK	4	Number of consecutive time program can attempt to alleviate choking (if iterating for W) (initialized = 10)
	LMCHTØ	4	Total no. of terms choke alleviation can be attempted during a case (initialized = 30)
	LIMTRY	4	Maximum no. of times program can iterate for W. (initialized = 15)
	NØPRT	4	>0 print no input data nor output results except for summary table of 8" major variables" (PTIN, TTIN, TTEX, PTEX, PSEX, TWMAX, W, QTØT); = 0 no action.
	PARPRT	4	> 0 for each case, print no input data nor output results except for the 8 "Major variables"; = 0 no action.
	STAGES (* NØSTGE)	4	No. of stages (max of 100)
	PRTSUM	=	> 0 immediately print the full summary table of 8 "major" variables which otherwise prints only after 100 calculations (automatically reset-= after use); = 0 no action.

	ALLRUN	4	>0 always, if possible, carry out calculations for any record in which no error or omission was found regardless of what occurred during previous records; = 0 carry out no calculations once an error or omission has been found but merely search remaining records for DIP-type errors.	
	TØTLEN	3	Total length of passage, to be used with stage lengths specified by XØL (X/L)	
	XØL$_{100}$	3	Fraction of total length to current stage exit.	
	CASE(KASE)	4	Case number (initialized = 1)	
	CASTEP(KASTEP)	4	Interval between case numbers for automatic case numbering (initialized = 1)	
ϕ_s	PHISUM$_{100}$	3	Fraction of total power released by end of current stage.	
ϕ_x	PHIEX$_{100}$	3	Stage exit to stage average power	
	P0,P1,P2$_{100}$	3	Tabular power profile; stage entrance, midpoint, and exit tables, respectively.	
	PTXØPI	3	PTEX/PTIN, an alternate way of specifying PTEX	
	PSXØPI	3	PSEX/PTIN, an alternate way of specifying PSEX.	
	TEXØTI	3	TTEX/TTIN (ratio based on absolute temperature), an alternate way of specifying TTEX. (Not necessary to load TTIN in deg. R)	
	NØPTIN	4	No. of parametric entries for	PTIN
	NØTTIN	4	(zero and one treated as	TTIN
	NØTWMX	4	equivalent)	TWMAX
	NØQTØT	4	(** KPARAM)	QTØT
	NØPSEX	4		PSEX
	NØPTEX	4		PTEX
	NØW	4		W
	NØTTEX	4		TTEX
	DPTIN	3	Increment for parametric	PTIN
	DTTIN	3	steps for (units as loaded)	TTIN
	DTWMAX	3	(** DPARAM)	TWMAX
	DQTØT	3		QTØT
	DPSEX	3		PSEX
	DPTEX	3		PTEX
	DW	3		W
	DTTEX	3		TTEX

	AUTØLS	3	>0 calculate automatic interstage loss coefficient if area change encountered.
	$CLSMØD_{101}$ ($CLSMDI_{100}$)	3	Multiplier for automatically generated interstage loss coefficient. (initialized ≡ 1)
	$NCLSMD_{100}$	4	Distribution variable for CLSMOD
L_w L_h	$WIDTH_{101}$(DHD) $HEIGHT_{101}$(AFFD)	3 3	Width and height of rectangular passage from which D_h and A_{ff} are to be automatically calculated.
D_{maj} D_{min}	$ELPMAJ_{101}$(DHD) $ELPMIN_{101}$(AFFD)	3 3	Major and minor axes of an elliptical passage from which D_h and A_{ff} are to be calculated.
D_{outer} D_{inner}	$DØUTER_{101}$(DHD) $DINNER_{101}$(AFFD)	3 3	Outer and inner effective diameter of concentric ring assembly (half-rings at inner and outer surface.)
t_{ring}	$THICK_{101}$	3	Thickness of individual ring in concentric ring assembly.
n	$NØRING_{101}$	4	No. of rings in concentric ring assembly, including inner and outer half rings.
	RECTNG	4	>0 cross section is rectangular.
	ELLIPS	4	>0 cross section is elliptical
	RINGS	4	>0 cross section is concentric ring assembly.
	$HMULT_{101}$	3	Stagewise multiplier on calculated heat transfer coefficients (all initialized ≡ 1)
	$NHMULT_{100}$	4	Distribution control for HMULT
	$FMULT_{101}$	3	Stagewise multiplier on calculated friction factors (all initialized ≡ 1)
	$NFMULT_{100}$	4	Distribution control for HMULT
	HEADER ($HEDDUM_{12}$)	B	Heading comment
	CIN,CEX	3	Entrance and exit loss coefficients
	LIMPRS	4	Counter limit on pressure and wall temperature iterations for one stage. (initialized ≡ 20)

PRTALL	4	Print complete stage output including dynamic pressures, static pressures, heat transfer coeff, friction factors, and automatically generated interstage loss coefficients, if any.
MAXMNØ (ØMAXD)	3	Starting value for max passageMach No. to match in choking remedial (where possible) (initialized = .5)
NØINPT	4	Suppress all input printout.
MAXTMP	4	Stage at which TWMAX is to be obtained when iterating to match TWMAX. Zero means hottest stage is used.
LMBULK	4	>0 use bulk temperature for laminar heat transfer correlation.
TBBULK	4	>0 use bulk temperature for turbulent heat transfer correlation
TRANSF	3	Transition N_{Re} for friction factor (initialized = 2300)
TRANHL	3	Lower bound for N_{Nu} transition region (initialized = 2000)
TRANHU	3	Upper bound for N_{Nu} transition region (initialized = 8000)
NEWSET	4	>0 replace BSI table by BSO. Enables retrieval of newly calculated quantities to be used as subsequent design contraints during a given machine run. In the event that the case fails, will result in program exiting regardless of ALLRUN will also fill QBAR.
QBAR	3	Reference heat release level. (Can be internally filled by QØQBAR) (BUT/sec)
QØQBAR	3	QTØT/QBAR. Will override a QTØT input value.
NØGEØM	4	>0 do not print geometrical and power profile input.

VIII.2 Internal Variables

Math Symbol	Mnemonic	Purpose
	KTRCRD	DIP record counter
	KALCNØ	Sequential number of successful calculation
	DEAD	>0 means some kind of error found. Causes searching of DIP records for DIP errors unless ALLRUN >0. If $= 0$, no action.
	KTCHAD	Counts choke adjustments for a single wt. flow.
	KTWADJ	Counts wt. flow adjustments
	KTCHTØ	Counts total choke adjustments for a case.
	BSI_{11}	Grouping variable for 8 major input variables + 3 ratios.
	$BSØ_{11}$	Grouping variable for 8 major output variables +3 ratios.
	DHD_{100}	Input hydraulic diams. with offset removed.
	DHI_{100}	Calculation table of hydraulic diams.
	$AFFD_{100}$	Input free flow areas with offset removed.
	$AFFI_{100}$	Calculation table of free flow areas.
	$ØLEND_{100}$	Input stage lengths with offset removed.
	$ØLENI_{100}$	Calculation table of stage lengths.
	TØTLND	Calculation total passage length.
	$XØLD_{100}$	Calculation table of X/L stations
	$CLØSSD_{100}$	Input interstage loss table with offset removed.
	$CLØSSI_{100}$	Calculation table of interstage loss coefficients.
	PIND	Calculation value of PTIN
	TIND	Calculation value of TTIN
	TWMAXD	Calculation value of TWMAX
	TEXD	Calculation value of TTEX
	QTØTD	Calculation value of QTØT

VIII.2 Internal Variables (continued)

	PEXD	Calculation value of PTEX
	PSEXD	Calculation value of PSEX
	WD	Calculation value of W
	$GRTMPI_3$	Grouping variable for temperature input
	$GRTMPØ_3$	Grouping variable for temperature calculations
	$FTABI_4$	Grouping variable for friction factor data
	$HTABI_6$	Grouping variable for heat transfer data
	NSKPPR	> 0 skip pressure drop calculations = 0 no action.
	NSKPHT	> 0 skip heat transfer calculation = 0 no action
	ENTRN	Calculation entrance length effect signal.
	KPØW	> 0 Power profile loaded. = 0 no power profile loaded
	KØPT	Carries calculation option number, if any
	KØSCIL	Counter to detect if iteration is "oscillating" and tighter tolerances might be required on press drop and Mach No.
	SVACMN	Saves original Mach No. accuracy
	SVACPR	Saves original press drop accuracy
	ITRY	Independent variable iteration counter.
	TRY0,1,2,3	Iteration values of independent variables
	GOAL	The quantity which the iteration is trying to satisfy.
H_{in}	HIN	Inlet enthalpy
H	DELH	Total enthalpy release
G	$GMASS_{100}$	Mass velocities
T_{exi} or T_b	$TEXI_{100}$	Stage exit bulk temperatures
	KCHØKE	Choke signal; if > 0, gives stage where choke occurred.

YIELDO,1,2	Current value of quantity being iterated for
TESTL	A difference used in determining whether convergence achieved.
NT,LØC	Used for error identification.
DERIV	The "straight-line" derivative
AD,BD,FD	Coefficients in 3-point fit.
MØRCAS	>0 means more cases to be parametrically generated without reading in anymore data; = 0 read in more data.

KPARMR(M) M=1	Internal parametric counters for	PTIN
2	(always initialized one less	TTIN
3	than input value)	TWMAX
4		QTØT
5	($KPARMR_8$)	PSEX
6		PTEX
7		W
8		TTEX

$KPARAM_8$	Groupting variable for input parametric counters. (used for resets)
$FPARMI_8$	Grouping variable for starting values of the 8 major flow variables (used only in parametric studies).
$DPARAM_8$	Grouping variable for input parametric increments.

DPARMI(M) M=1	Grouping variable for internal parametric	PTIN
2	increments with needed unit changes.	TTIN
3		TWMAX
4		QTØT
5		PSEX
6		PTEX
7		W
8		TTEX

FSTPAR	>0 signals that first parametric case is being carried out; = 0 not first case.
NTWMAX, NØTWMA	Variations of NØTWMX
$KPARMR_8$	Running counters for parametric studies.

	PIN TIN PEX TEX	Variations of PTIN, TTIN, PTEX,TTEX
	$KØNØPT_{2,10}$	Table to enable convenient retrieval of variables associated with iterations to satisfy option (preset)
	$KØNPAR_{4,13}$	Table (preset) which retrieves appropriate counters during parametric studies.
	$KSHIFT_{72}$ KUP_{72}	Grouping variables used in lower and COMMON memory, respectively, for transfer fill of KØNØPT and KØNPAR
C_L	$CLSGEN_{100}$	Automatically generated interstage loss coefficients.
	PSPID(BSØ(9))	PSEXD/PIND
	PTPID(BSØ(10))	PEXD/PIND
	TXTID(BSØ(11))	TEXD/TIND
	$SAVTAB_{13,100}$	Grouped summary table. 2 thru 11 correspond to BSØ(1-11). SAVTAB(1) used for case number. SAVTAB(13) = NHØT
	NHØT	Stage no. where TWMAXD located
	$KRSCØN_4$	Cross section control group (in priority sequence)
	KRT	A logical routing variable
	ND	A dummy subscript
	K1,K2,K3	Backspacing controls for cross-section processing
	AFFLØC THKLØC NRGLØC	Dummy variables used in backspacing logic
	FRINGS	Floating point version of local no. of rings.
	$NRINGD_{100}$	Internal (offset) version of NØRING
	$THICKD_{100}$	Internal (offset) version of THICK
	$BWHEN_2$	Units; input or output (H)
	$BUNLEN_{4,2}$	Units; inch or foot (H)

VIII.2 Internal Variables (continued)

	BUNTMP$_2$	Units; F or R (H)
	HEDDUM$_{12}$	Table for heading comment
T_w	TW$_{100}$	Trailing edge surface temperatures
M_{ex}	ØMEXI$_{100}$	Stage exit Mach Nos.
N_{Re}	REYNØ$_{100}$	Stage average Reynolds No.
h	CØNVEC$_{100}$	Heat transfer coefficients
f	FRIC$_{100}$	Friction factors
	DPINT$_{100}$	Interstage pressure losses
	KFIRST	Dummy variable used in MAIN to check SR ERROR returns.
	DUMDIP	Used in SR READIN to skip first DIP list
	ØMAXD	Internal mnemonic for MAXMNO
	ØMAX	Maximum passage Mach No.
	ØMAX1	Current criteria for maximum Mach No.
	KØPTH	$\leq$ 0 means KOPT $>$10.
	WHI	Lowest choking mass flow or highest non-choking inlet pressure
	WLØ	Highest non-choking mass flow or highest choking inlet pressure.
	DMCØNV	Dummy convergence criteria used for iterations (may be ACCPRS or ACCTMP)
	KDI	Subscript which retrieves independent variable from BSO
	KDD	Subscript which retrieves dependent variable from BSO
	KD1,KD2,KD3, etc.	Dummy subscripts
	PRTCRS$_{2,5}$	Table with mnemonics to identify cross section
	CRSHD1,CRSHD2$_{8,4}$	Format inserts for cross section printout format.
	TRYMAX	High value of best bound for independent variable.

VIII.2 Internal Variables (continued)

	PDYIN	Inlet dynamic pressure, after entrance loss
	PDYEX	Exit dynamic pressure, before exit loss
	ØMINLT	Entrance Mach No. after entrance loss
	ØMEXIT	Exit Mach No. before exit loss
	REYNIN	Entrance Reynolds No., after entrance loss
	DPIN	Entrance loss, tot press.
	DPEX	Exit loss,tot press.
P_{sexi}	$PSEXI_{100}$	Stage exit static pressures
P_{dyn}	$PDYEXI_{100}$	Stage exit dynamic pressures
	TRYMIN	Low value of best bound for independent variable
	TESTP	Smallest difference between GØAL and yield; yield< GOAL.
	TRYP	Value of independent variable associated with TESTP; used as a bound.
	TESTM	Smallest difference between GOAL and yield; yield > GOAL.
	TRYM	Value of independent variable associated with TESTM; used as a bound.
	T1	Dummy used as old value of independent variable in testing for increment to new value.
	T2	Dummy used for new value of independent variable in testing for increment to new value and testing whether new value lies between bounds.
	$TSTGRP_4$	Groups TRYP,TESTP,TRYM, and TESTM
	KTØTPR	Total no. of cases to be generated in parametric study.
	KTPAR	Counter on no. of parametric case tried.
	KASESV	Used to save original case number when performing parametric studies.
X	SUMLEN	Distance from beginning of passage to end of current stage
M_{in}	ØMINI	Entrance Mach No. for current stage.

VIII.2 Internal Variables (continued)

P_{ini}	PINI	Entrance total pressure for current stage
$T_H(\ )$	TMPENT(-1 mode)	Temperature as a function of enthalpy
$H_T(\ )$	TMPENT(1 mode)	Enthalpy as a function of temperature
T_{ini}	TINI	Inlet total temp. to current stage
γ	GAM( )	A function for Cp/Cv
g		Conversion factor 32.17
R	R()	A function for the gas constant
T_f	TAVG	Film temp, in SR TWLT. Otherwise, stage average bulk temperature.
μ	VISC( )	A function to calculate absolute viscosity
k	TC( )	A function to calculate thermal conductivity
η	ETA	Curve-fitting parameter in transitional heat flow.
N_{Re_1}	TRANHU	Upper Reynolds No. limit for transitional heat flow.
N_{Re_o}	TRANHL	Lower Reynolds No. limit for transitional heat flow.
H_{calc}	ENTRY	A calculated value of stage enthalpy release during surface temperature "iterations".
ψ	PSI	An intermediate variable used in SR LOSS
N_{Nu}	STGNNU	Stage Nusselt No.
N_{Pr}	STGPRN	Stage Prandtl No.

VIII.3 Miscellaneous Notation

Math Symbol	Definition
P_T	A total pressure
T_T	A total temperature
W_{est}	A value of mass flow as independent variable
$P_{ex-calc}$	An exit pressure, static or total, calculated during iterations
$P_{tin-est}$	A value of inlet total press. as independent variable
A	A flow area
f_{∞}	A fully developed friction factor
$N_{Nu\,\infty}$	A fully developed Nusselt No.

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6. Shapiro, A. H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald, New York, 1953. Chapter 8.

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Table 1 - Subroutines Coded Especially for GFP

NAME	PURPOSE	CARDS
MAIN	Controls calling of major subroutines.	0002 - 0097
CØNSIS	Checks adequacy and consistency of data. Also selects calculation option.	0099 - 0347
DATPRØ	Handles transfers and distribution from input tables to calculation tables. Also handles unit changes.	0349 - 0658
DPFRLT	Pressure drop calculation.	0660 - 0913
INITAL	Performs all pre-load initialization.	0970 - 1137
INPPRT	Handles printout of input data.	1140 - 1523
ITRCØN	Handles the entire execution of the calculation option.	1525 - 1939
ØUTPUT	Prints normal output.	1941 - 2280
READIN	Contains DIP-list and DIP error checker. Has optional feature which allows program to run from future records if sufficient data are present.	2282 - 2539
RESET	Erases most of calculation data fields in preparation for a change case.	2541 - 2661
SETYLD(I,A)	Selects the current value of the iteration yield from DPFRLT output. (Zero arg I extracts all possible yield variables)	2663 - 2730
SUMPRT	Prints data summary (up to 100 runs)	2732 - 2929
TWLT	Wall temperature calculation.	2931 - 3292
UNCHKE	Adjusts mass flow in event of choke if option permits.	3294 - 3509

[illegible] Non-departmental Utility Subroutines

NAME	PURPOSE	CARDS
GAM	Computes c_p/c_v (γ) as function of temperature	3511 - 3560
LMPRØP	Prints comment when temp limit of property exceeded.	3562 - 3585
NØPRØP	Prints comment when property not available for a specific gas.	3587 - 3605
PRN	Computes Prandtl No. (N_{Pr}) as function of temp.	3606 - 3655
R	Yields gas constant for selected gases.	3657 - 3688
TC	Computes thermal conductivity (k) as function of temp. (BTU/sec-in-$^{\circ}$R)	3691 - 3742
TMPENT	Function yielding temperature or enthalpy.	3744 - 3862
VISC	Computes viscosity (μ) as function of temp (lbm/ft-sec)	3864 - 3908
AMACH	Computes Mach No. from total properties	3910 - 3928
CØNTMP	Converts Fahrenheit temps to Rankine or vice versa	3930 - 3957
DSTRBL	Used to distribute data in tables.	3959 - 4012
DYPRS	Computes dynamic pressure from total properties	4014 - 4024
EXTRAP	Performs linear (with 2 pts.) and quadratic (with 3 pts.) extrapolations.	4026 - 4062
FLWFUN	Computes mass flow from total properties	4064 - 4072
FPRNT	Checkout print of floating point data.	4074 - 4082
LØSS	Computes incompressible sudden expansion and contraction losses.	4084 - 4124
NETERR	Prints error codes.	4126 - 4139
PØWER3	Uses Simpson's rule to integrate tabular power profiles	4141 - 4167
PRSFUN	Computes total pressure from flow and remaining total properties.	4169 - 4176
PSTAT	Computes static pressure from total properties.	4178 - 4185
TBINSP	Inspects first card of input data record.	4187 - 4211
XPRNT	Checkout print of fixed point data.	4213 - 4221

Figure 1 - Logical Flow Chart of the GFP Main Program

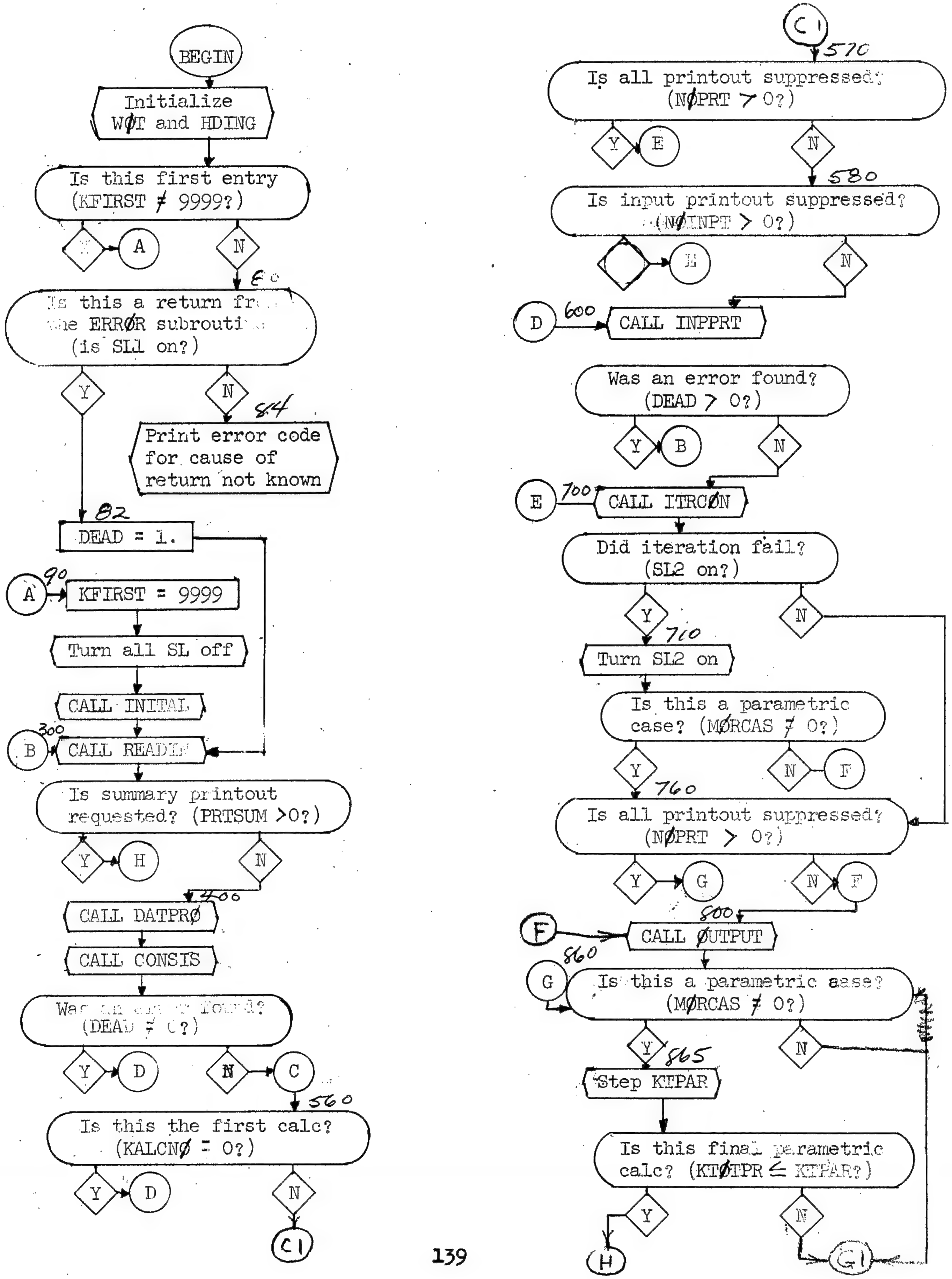


Figure 1 (continued)

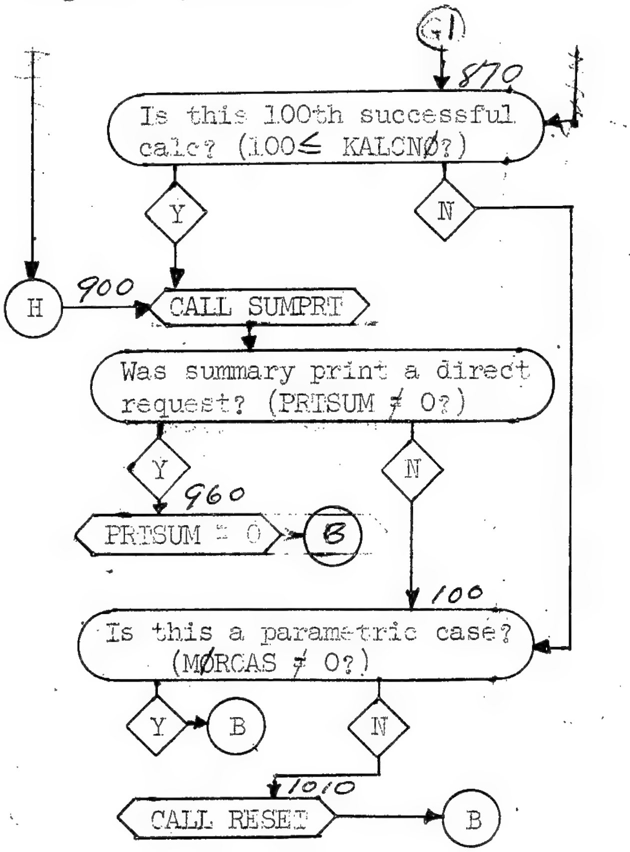


Figure 2 - Logical Flow Chart of the Iteration Control Subroutine (ITRCON) for the General Flow Passage Program

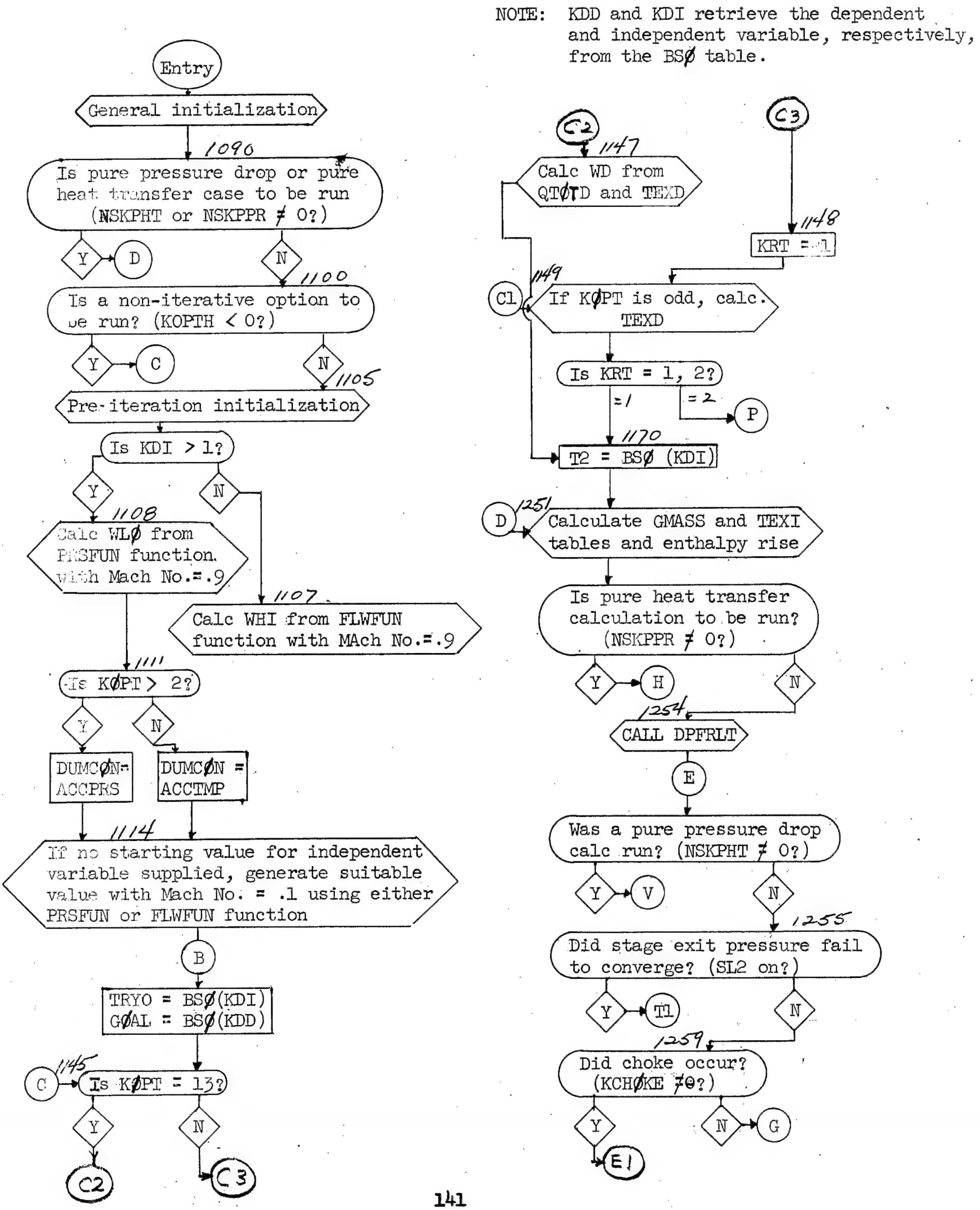


Figure 2 (continued)

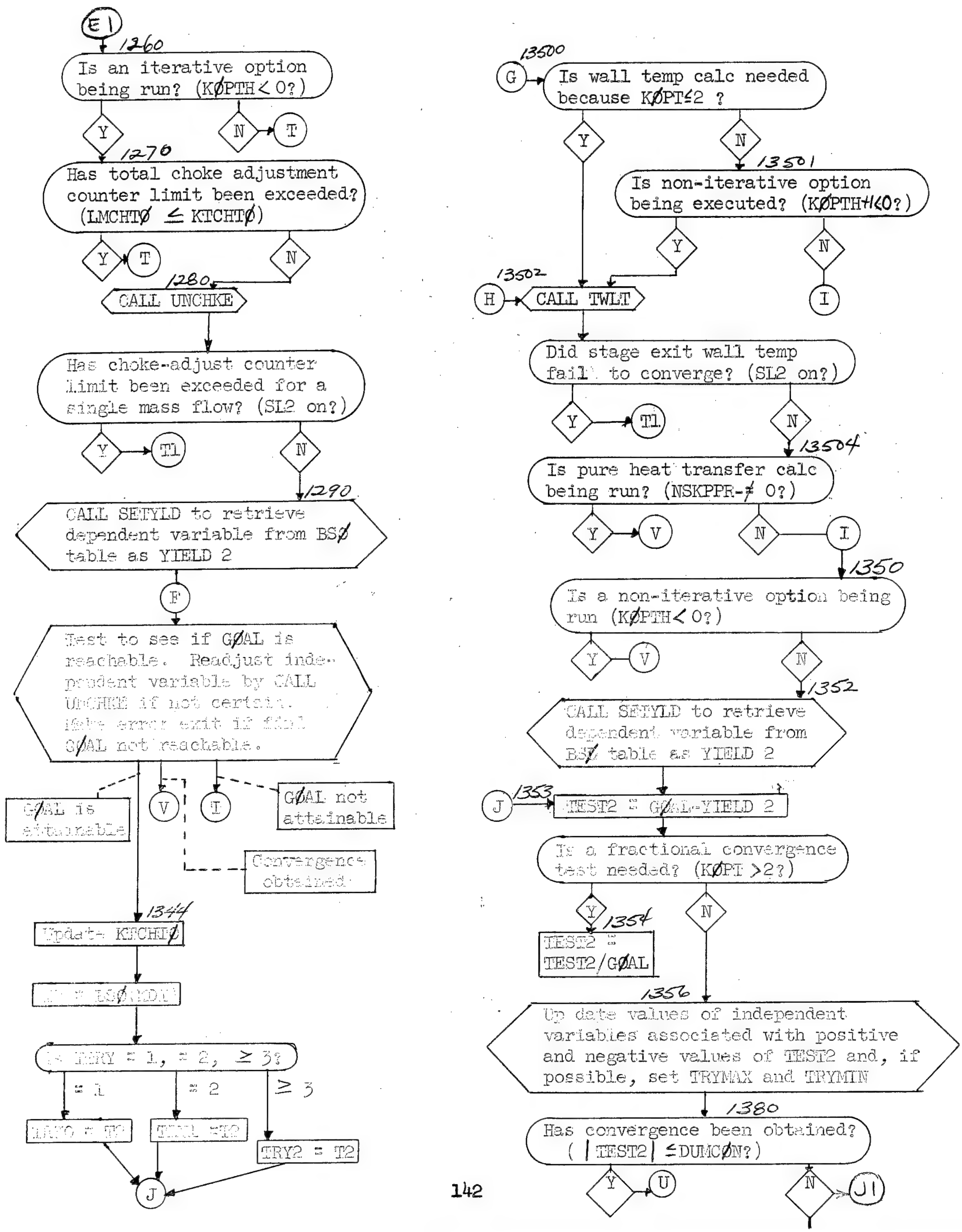


Figure 2 (continued)

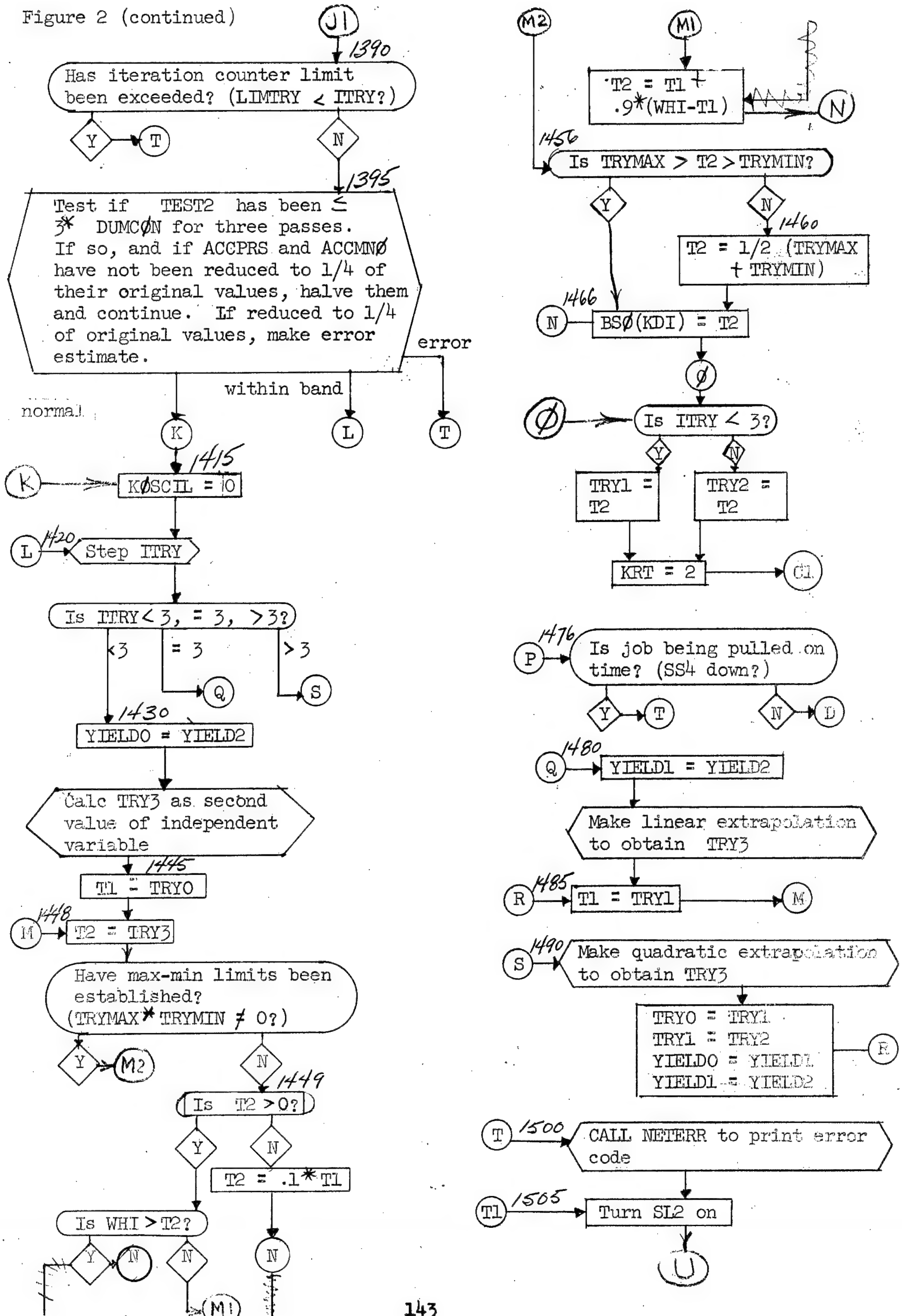


Figure 2 (continued)

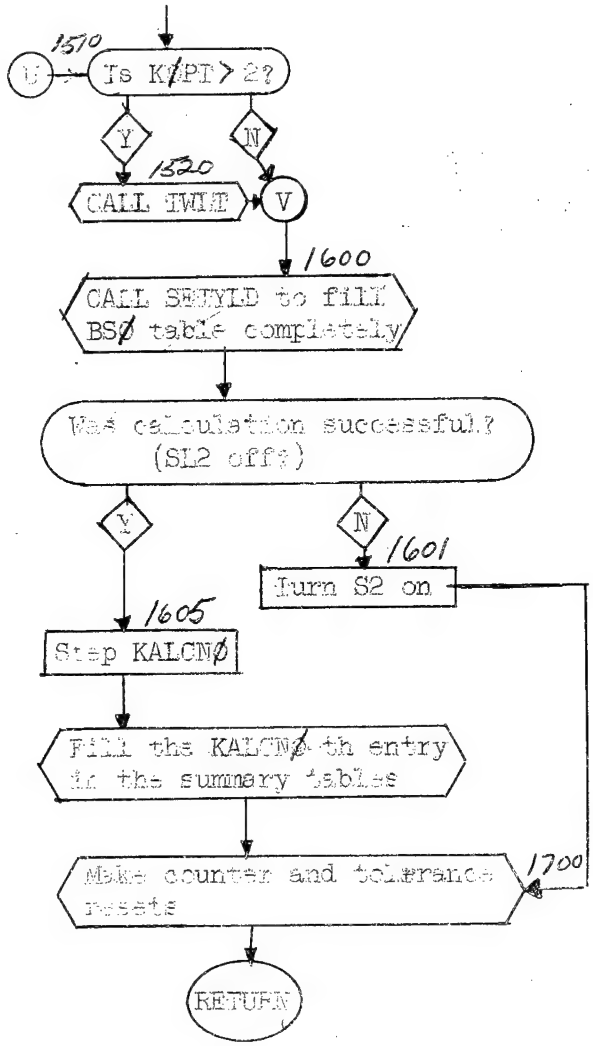


Figure 3 - Logical Flow Chart of the UNCHKE Subroutine for the General Flow Passage Program

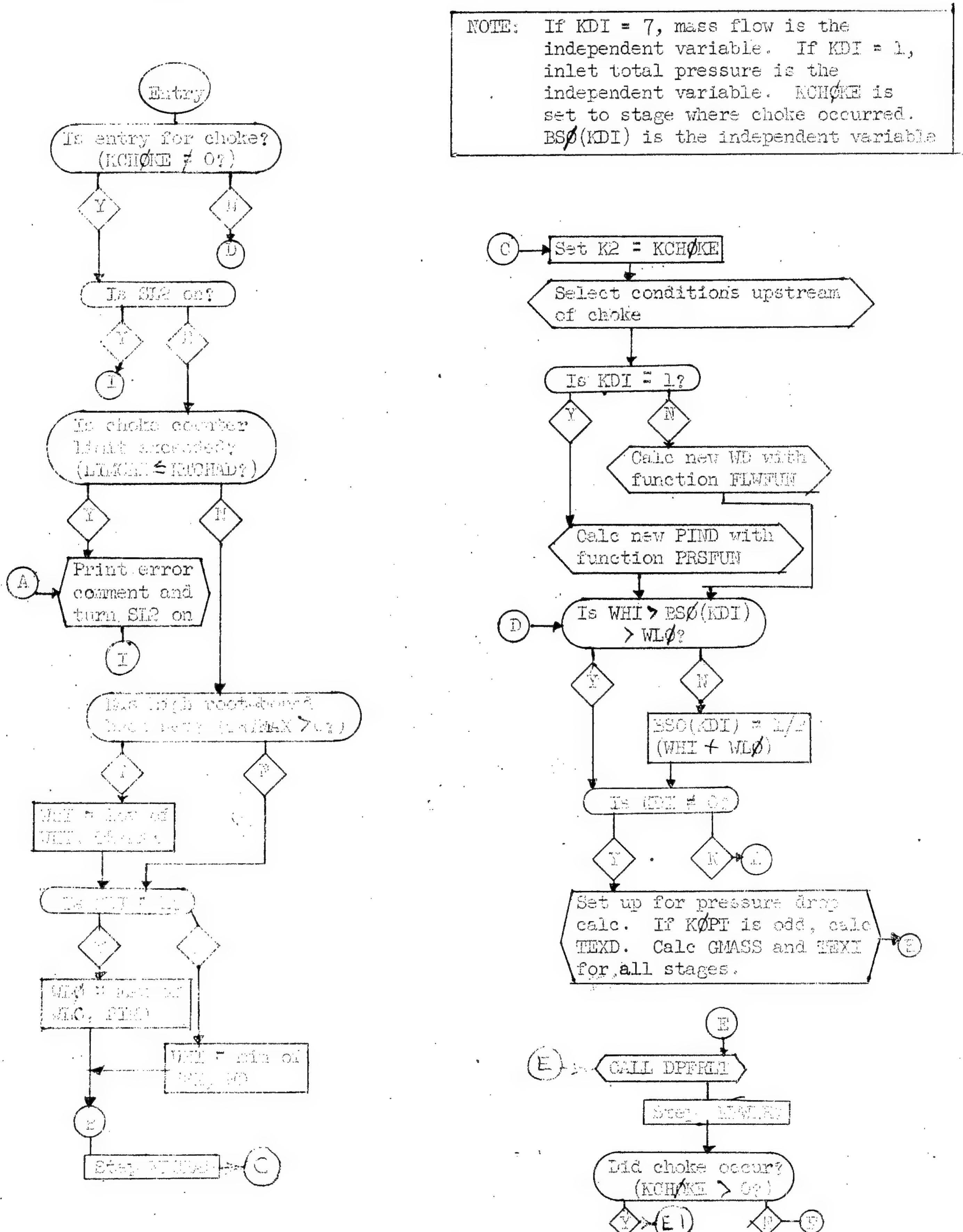


Figure 3 (continued)

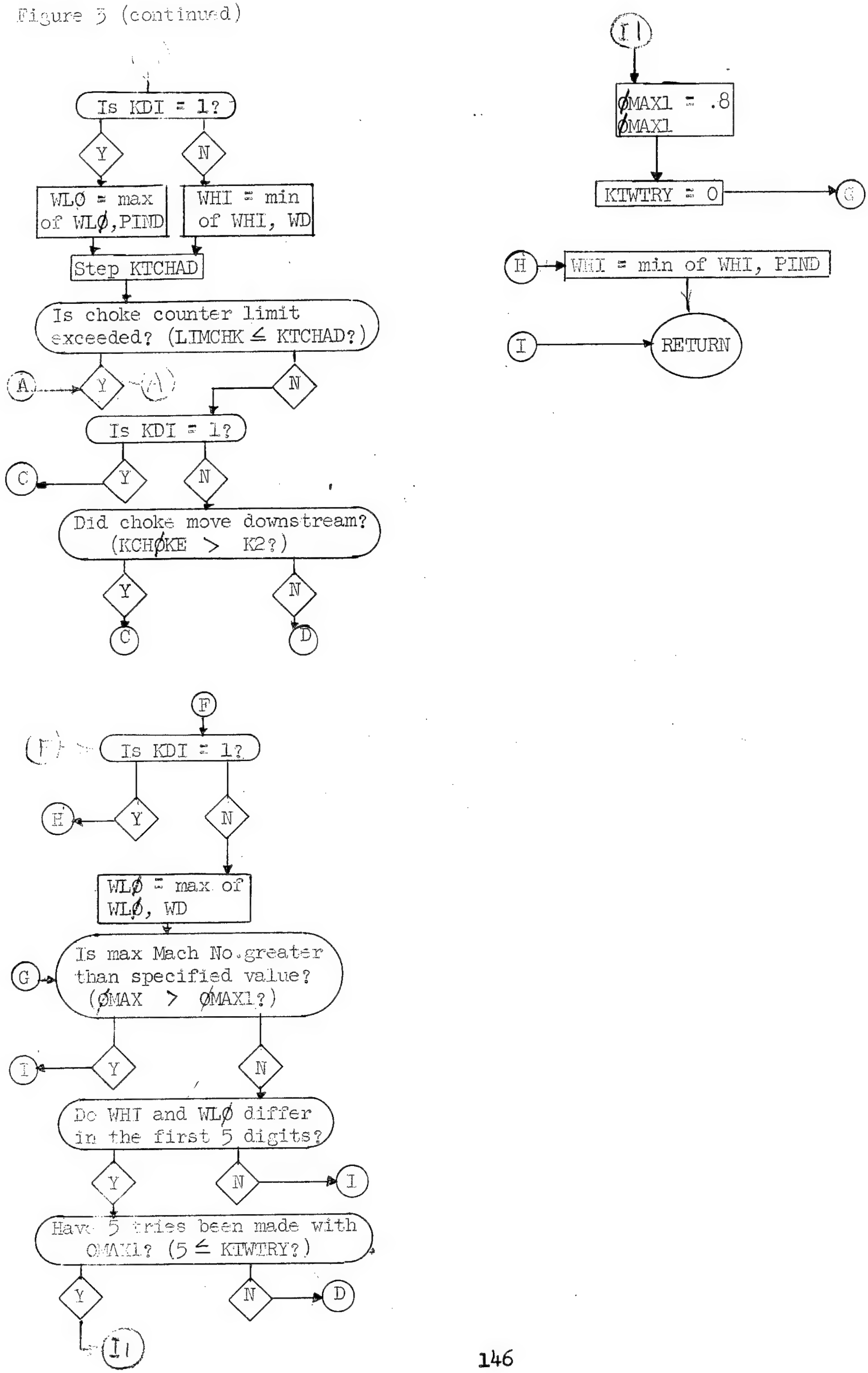
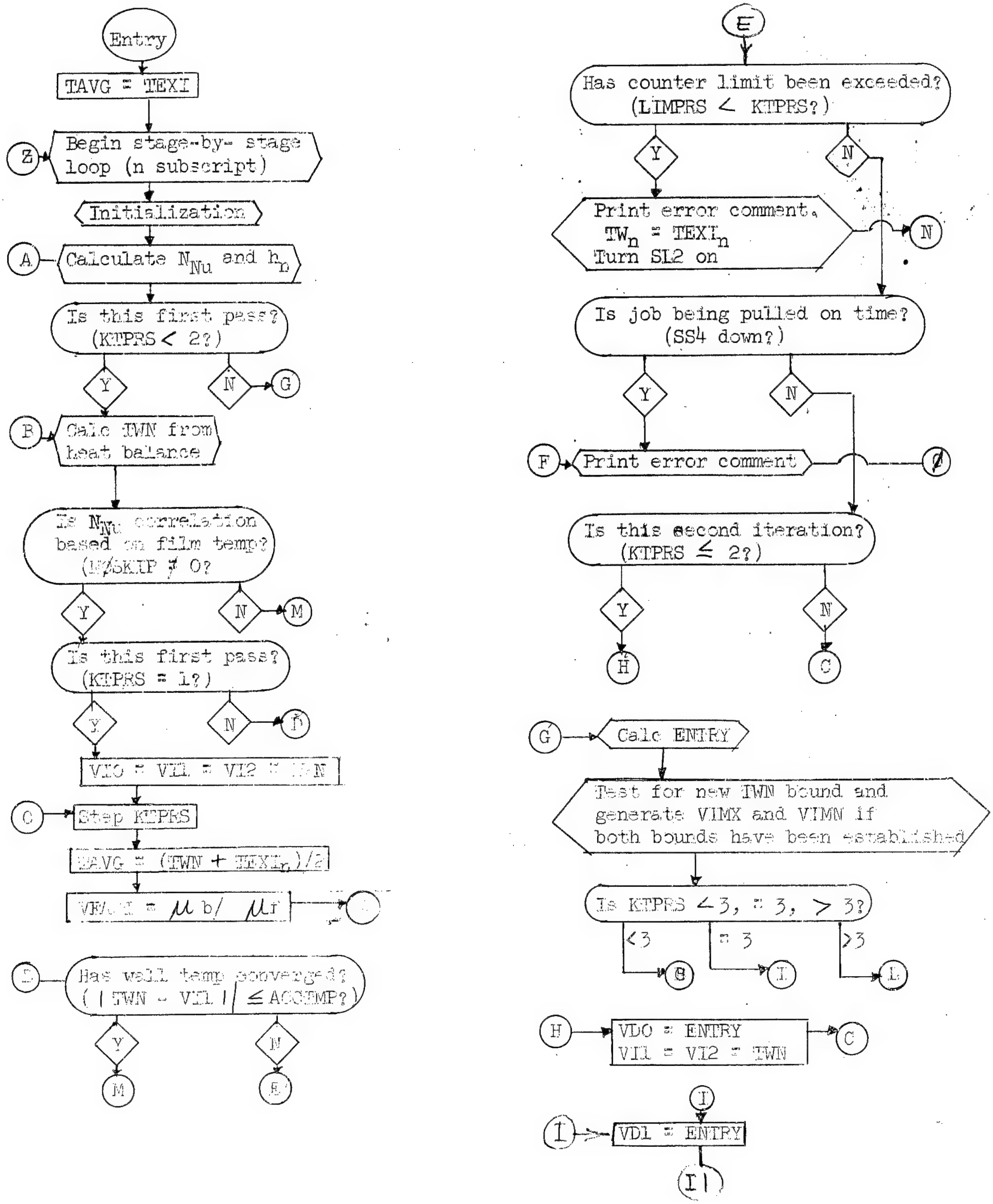
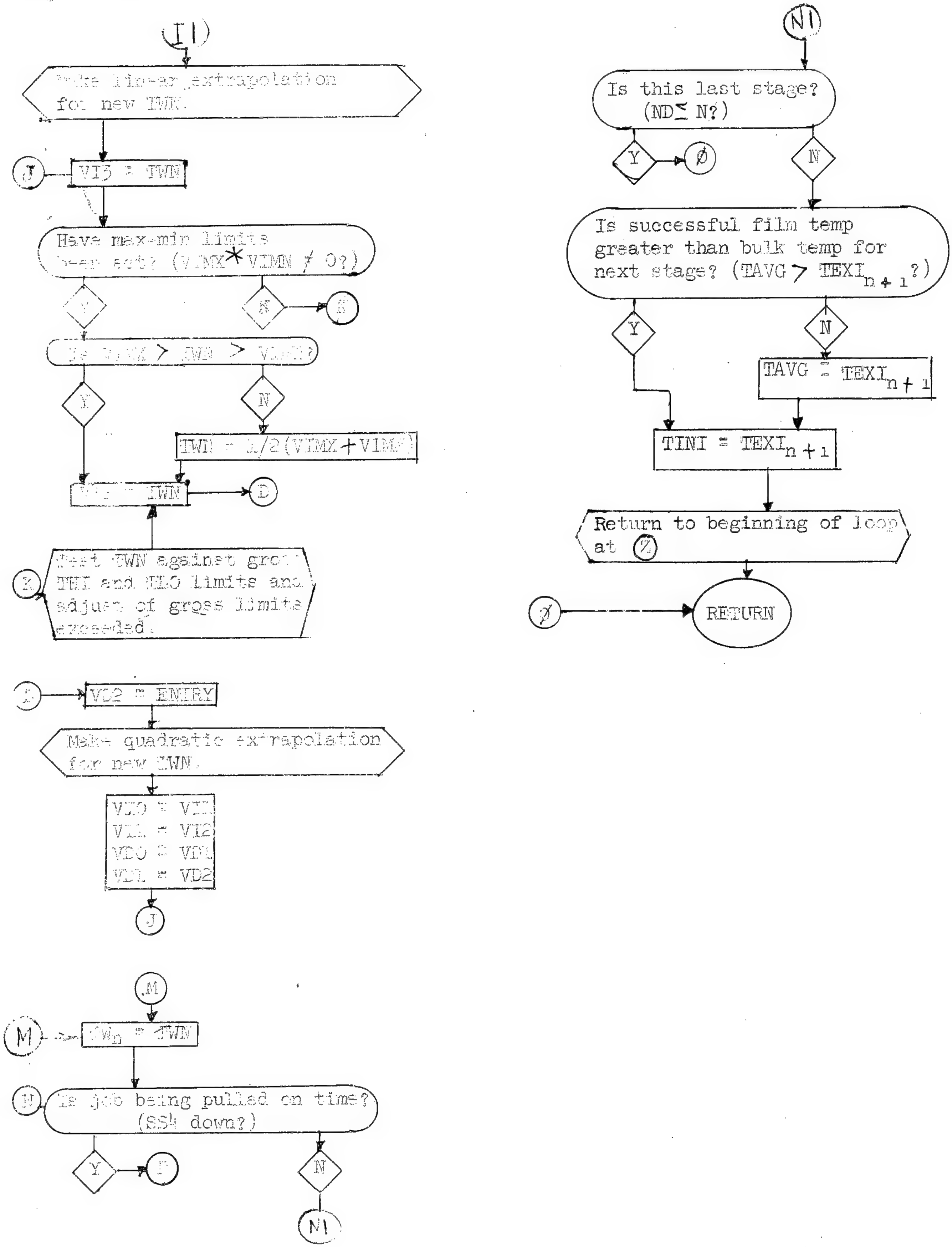


Figure 4 - Logical Flow Chart of the Surface Temperature Calculations (in Subroutine TWLT) for the General Flow Passage Program





I1
for new TWN.
J
VI3 = TWN
Have max-min limits
(VIMX * VIMN ≠ 0?)
N
D
Test TWN against gross
and
limits and
of gross limits
exceeded.
K
VD2 = ENTRY
Make quadratic extrapolation
for new TWN.
VD2
J
M
M
= TWN
Is job being pulled on time?
(SS4 down?)
Y
N
N1
N1
Is this last stage?
(ND ≤ N?)
Y
Ø
N
Is successful film temp
greater than bulk temp for
next stage? (TAVG > TEXI n+1?)
Y
N
TAVG = TEXI n+1
TINI = TEXI n+1
Return to beginning of loop
at
RETURN
Ø

Figure 5 - Major Param[illegible] Control Logical Flow Chart for the GFP Program (in Subr[illegible])

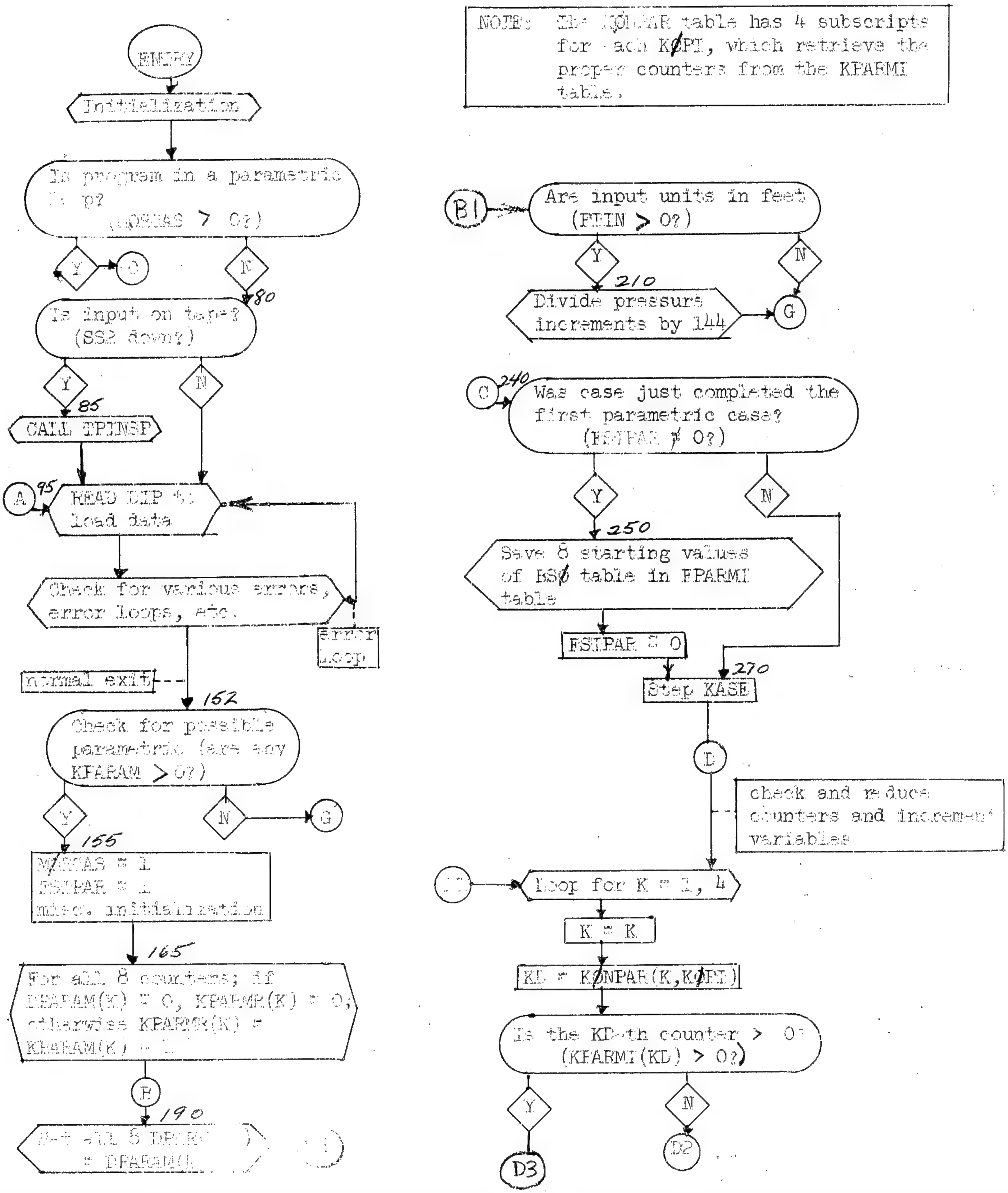
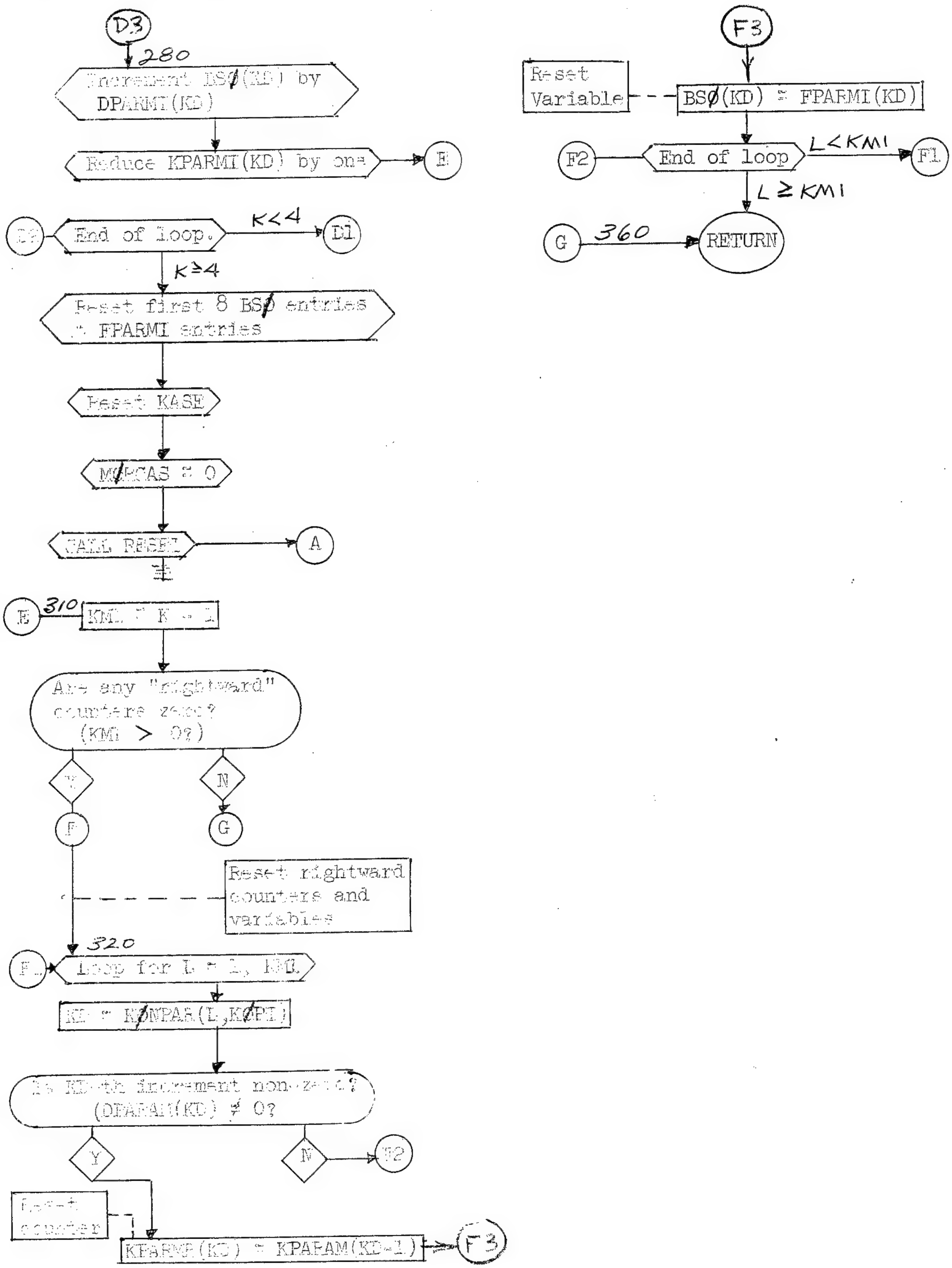


Figure 5 (continued)



APPENDIX A. Thermal Property Functions

The following temperature-dependent functions are required by GFP:

Viscosity	VISC
Thermal conductivity	TC
Specific heat ratio (c_p/c_v)	GAM
Prandtl Number	PRN
Enthalpy	TMPENT(+1 mode)

In addition, temperature as a function of enthalpy is required in order to compute bulk temperature levels. All properties employ the appropriate units from a lbm, sec, inch, BTU, and deg R system except for viscosity which, as a result of an unfortunate act of expendiency in the past, is used in lbm/ft-sec.

All properties are encoded as Fortran II functions in the form of polynomials determined from least-squares curve fits and all have as the final argument in their lists the variable GAS. The sources of data are included in the source deck listings. GAS is a floating point variable which designates the gas whose property is to be calculated according to the following table:

Value	Gas	Available
1	Air	X
2	Nitrogen (N_2)	
3	CO_2	
4	Hydrogen (N_2)	X
5	Oxygen O_2	
6	Helium	X
7	Argon	
8	Freon	
9	Neon	X

Only those gases marked with X's have properties available, except for the relatively minor gas constant function R. Additional gases can be readily incorporated.

With the exception of the temperature-enthalpy functions which will be discussed later, all of the property functions have the following features in common:

1) All are "built" for a maximum of a sixth degree polynomial.

2) All have tables which give the lower and upper temperature limits for each gas (tables TMPLØW and TMPHI, respectively). If the function is given a temperature which lies outside the limits for a given gas, the function is evaluated at the nearest temperature limit and the subroutine LMPRØP is called to print out a comment which tells the property, the gas, the temperature limits, and what temperature was tried.

3) If a given function is given a value of GAS for which it does not have a property polynomial, the subroutine NØPRØP is called to print out the property name and the gas and the property is evaluated for air.

The TMPENT function is used to calculate enthalpy as a function of temperature (+ mode) and temperature as a function of enthalpy (- mode). The least-squares curve-fits used are based on the same data; the first with temperature as the independent variable and the latter with enthalpy as the independent variable. Since neither curve fit is "perfect" for the data, one cannot assume a temperature, calculate the enthalpy, and use the calculated enthalpy to recompute the original temperature.

In order to avoid this discrepancy, a root-finding technique was employed for the TMPENT function when computing temperatures.

The basic equation used to calculate enthalpy as a function of temperature (and in all other property functions except TFRMEN) can be written as

$$y = \sum_{n=0}^{6} a_n T^n \tag{A-1}$$

where T represents absolute temperature and y is the appropriate dependent property. The inverse curve-fit used as a starting point in the calculation of temperature from enthalpy, can be written as

$$T = \sum_{n=0}^{6} b_n y^n \tag{A-2}$$

The problem of determining temperature from enthalpy is facilitated by defining a function f, one whose roots is to be determined, by

$$f = y - y^* \tag{A-3}$$

where y^* is the input enthalpy value. The desired value of temperature (which makes $f \approx 0$) is obtained by the Newton-Raphson method using the following formula for the i + 1-th improvement to the i-th value of the temperature:

$$T_{i+1} = T_i - \frac{f_i}{\left(\frac{df}{dT}\right)_i} \tag{A-4}$$

Equation (A-2) is used for the first cut on temperature, as noted. The derivative needed by formula (A-4) can be computed as

$$\frac{df}{dT} = \frac{dy}{dT} = \sum_{n=1}^{6} n a_n T^{n-1} \tag{A-5}$$

Iteration is halted when the difference between successive approximations become less than or equal to 0.049 degrees.

No temperature limits have been installed in the temperature-enthalpy functions. This decision has been made with some reluctance since it does allow a program user to exceed the valid bounds of the functions. However, a limit cutoff of the same type as installed in the other property functions would invalidate the temperature scale utilization of

the enthalpy-temperature relationships. A better arrangement, which the writer recommends to anyone who undertakes revision of the program, would be to have the LMPRØP subroutine print out its warning when the allowable range of the enthalpy-temperature correlations is exceeded, but to allow the evaluations to be performed at the requested temperature, rather than at the nearest temperature limit.

APPENDIX B. ANP Department Subroutines Used in the GFP Program (not from the standard Fortran Library)

fortran

STHA

IDENTIFICATION:

Storage to Tape Hollerith
J. A. Delaney
GE-ANP - Evendale
November 17, 1959

PURPOSE:

To write a BCD record on tape for off-line printing and perform the following:

1. Examine column 1 for a legal carriage control character and space the printer accordingly.

2. Count the number of lines printed on a page and cause the printer to restore the paper after reaching the maximum of 55 lines. Thus, print-out over the perforation is avoided.

3. Automatically number the pages.

4. Automatically print a heading, if one has been specified, at the top and bottom of each page.

5. Supply to the program the number of lines already printed on the current page.

6. Supply the current page number to the program.

USAGE:

This subroutine may be inserted in any FORTRAN II deck and will automatically provide features 1, 2, and 3 above.

STHA retains the function of the subroutines CALL LINES, CALL PAGES, and CALL RESTØ of the version of (STH) written by W. F. COOK, FPD, April 23, 1959.

For a description of the other features, see the supplementary write-up.

LIMITATIONS:

1. Assumes the ANP standard 720 paper tape for printer control. (See supplementary write-up.)

STHA

2. Uses the following names as entry points:

   HDING, RESTØ, NØPAGE, NØHEAD, NEWSET, LINES, PAGES, CØLUMN, BØTTØM, ANPIPM

   To use STHA in an existing program which employs one of the above names for another subprogram, place STHA in the deck prior to the others. If the FORTRAN BSS loader finds more than one program with some particular name, the last program of that name loaded is the one executed.

3. For best results, the new version of the FORTRAN post mortem (called MEMD) should be used with STHA. If the older version PM is used, spacing may be off during the printout of the PM list and extra restores may occur. However, the spacing will correct itself after returning to the program from PM.

STORAGE REQUIRED:

STHA uses 554 words of storage.

NOTE: STHA has two control cards, identified STHA CON1 and STHA CON2. This was necessary because there is not enough space on one card to list all the entry points.

msp

USE OF OPTIONS IN STHA

I. SOURCE LEVEL - Once one of the subroutines 1 through 7 is called, it remains in effect until some future specifications is called to override it.

1. CALL CØLUMN (N)

   If N ≠ 72, page numbering will be at the right-hand corner of 120 column printout.

   If N = 72, page numbering will be at the right-hand corner of 72 column printout.

   If no CALL CØLUMN is used, 72 column printout will be assumed.

2. CALL NEWSET (N) - The next page will be numbered N. (This will also reset an indicator to print page numbers.)

3. CALL NØPAGE - Page numbering will be omitted.

4. CALL LINES (NL) - The number of lines already printed on the current page is returned as the value for NL.

5. CALL PAGES (NP) - The current page number is returned as the value for NP.

6. CALL HDING ( ) - When mention is made below of a 72 or 120 character heading, it is assumed that column 1 is not available, since that character is for carriage control. The subroutine will ignore the character specified for column 1 and insert the proper carriage control character.

   a. CALL HDING (B) - This specifies a heading for printout. B is the name of the lowest memory location of a 12 or 20 word vector (72 or 120 characters) of Hollerith information, which subsequently will be printed at the top and bottom of each page. If page numbering is taking place, the last 12 characters of the 72 or 120 character heading are not printed at the top of the page since this space is reserved for "PAGE XXX." The full 72 or 120 characters are available, however, at the bottom of the page, and so to avoid undesirable information there, a full 72 or 120 character heading must be specified even if the last 12 characters are blank.

   An example of a 120 character heading is

```
DIMENSION A(20)
EQUIVALENCE (A(2),B2),(A(11),B11),(A(20),B)
CALL HDING (B)
CALL COLUMN (120)
READ DIP B, B11, B2
```

The DIP input cards would be, (starting in column 1)

```
2B,9, 1st 54 heading characters
2B11,9, next 54 heading characters
2B2, 12
```

(The last 12 characters are used for page numbering at the top, and are desired to be blank at the bottom.)

For 72 column output, an example is, (starting in column 1)

```
DIMENSION A(12)
EQUIVALENCE (A(6),B6),(A(12),B)
CALL NØPAGE
CALL HDING (B)
READ DIP B, B6
```

DIP cards, (starting in column 1)

```
2B,6, 1st 36 characters
2B6,6, next 36 heading characters
```

(All 72 columns are available since no page numbering will occur.)

NOTE: Although CALL HDING (B) may be used prior to the READ DIP statement which reads in the heading, care should be taken that no output statement requiring a new page occurs between the two. Otherwise, the present contents of B, probably all zeros, will be used as the heading.

b. CALL HDING(120H...(heading)...) or
   CALL HDING(72H...(heading)...)

   This alternate form may be used if the heading is known at source time.

7. CALL NØHEAD - A heading will not be printed unless one is later specified. This option is for omitting a heading that has been previously specified.

8. CALL RESTØ - The paper will be restored before the next line is printed.

9. CALL BØTTØM - The paper is spaced to the bottom of the page and the heading printed there, if one has been specified.

10. Illegal Control Characters - If X, the character in column 1, is not one of the standard control characters, a 0 (double space) will be assumed. Following this, a note will be printed out as follows:

    CONTROL CHARACTER *X* OF PRECEDING LINE IS NOT LEGAL

11. Legal Carriage Control Characters - The ANP standard carriage controls are

0	double space before printing
blank	single space before printing
+	no space before printing
1	restore before printing
2	skip up to 18 lines before printing
4	skip up to 6 lines before printing
8	skip to last line before printing

The characters 2 and 4 are used to skip to the last line of a certain fraction of the page. Control 2 will skip to the bottom of the current 1/3 of the page. That is, if the control character is 2, the line will be printed on line 19, 37, or 55, whichever comes first. Similarly, a control character 4 will skip to the bottom of the current 1/9 of the page. That is, printout will occur on line 7, 13, 19, 25, 31, 37, 43, 49, or 55, whichever comes first.

If there are no lines left on a page corresponding to a 2 or 4 control, i.e., either:

a. line 55 has been printed; or

b. the bottom heading is to be printed in line 55, and line 55 would correspond to the control,

the character 2 or 4 will have the same effect as a control character 1.

12. Standard Page - Of the 66 lines per page, 11 will be used for margin at top and bottom, leaving 55 lines per page for printout. If a heading has been specified, it will be printed on lines 1 and 55, leaving lines 2 through 54 available for 53 lines of print. If no heading has been specified, the page number will appear on line 1, leaving lines 2 through 55 available for 54 lines of print.

    If CALL NØPAGE has been used, lines 1 through 55 will be used for 55 lines of print.

II. OBJECT LEVEL - Many of the options discussed on the source level above may be used quite easily on the object level for existing programs if DIP is used.

In the following, "(STH)" is the location listed by MEMAP, that is, the entry point.

1. CØLUMN - If 120 column page numbering is desired, read a non-zero value into (STH) + 1.

2. NEWSET - To reset the page counter, read an integer N into (STH) + 3 and a non-zero value into (STH) + 2. Then the next page will be numbered N.

3. NØPAGE - Read zero into (STH) + 2.

4. HDING - A 72 or 120 character heading may be read (in BCD) into memory beginning at (STH) + 11_8 = (STH) + 9_{10}.

5. NØHEAD - Read zero into (STH) + 4.

msp

```
1SL    FORTRA
*SAMPLE CASE FOR STHA
      DIMENSION A(20),C(50)
      EQUIVALENCE(A(20),B),(A(11),B2),(A(2),B22)
  110 DO120I=1,50
  120 C(I)=I
  130 WRITE OUTPUT TAPE 3,1000,(C(I),I=1,50)
  140 CALL HDING(B)
  150 CALL NEWSET(10)
  160 CALL COLUMN(120)
      READ DIP B,B2,B22,D
  170 CALL RESTO
  180 WRITE OUTPUT TAPE 3,1000,(C(I),I=1,50)
  190 WRITE OUTPUT TAPE 3,1001,D
  200 CALL BOTTOM
      CALL NOPAGE
      WRITE OUTPUT TAPE 3,1000,(C(I),I=1,50)
  210 STOP
 1000 FORMAT(1H01PE14.5)
 1001 FORMAT(1H71PE14.5)
      END(0,1,0)
R         LOAD AND GO
2B,9,                                                       HEADING
2B2,9,READ  WITH  DIP
2B22,2,NOV. 24 1959
=D,12345,
```

Write Output Tape Subroutine - FORTRAN II

E. W. Klingenberg
GE-ANP - Evendale
September 1, 1959

Purpose:

To convert either a PRINT statement or a WRITE OUTPUT TAPE statement into the equivalent of both of these statements and to allow for the standard GE-ANPD sense switch 3 convention for output automatically if so desired.

Usage:

CALL WOT (N)

The WOT subroutine will control all PRINT and/or WRITE OUTPUT TAPE statements in the program which occur logically after the first use of the WOT subroutine, even when these output statements are in a different subroutine than the one which called WOT. The argument used will apply until another CALL WOT (N) statement is used to change the argument to another value. Either an integer or an integer variable may be used for the argument, thus allowing the programmer to fix the output or to place it under control of an input code word. By using a CALL WOT (N) statement with a different integer variable in the argument prior to each set of output, complete control of each set of output may be made a function of input. Regardless of whether a PRINT or a WRITE OUTPUT TAPE statement was used, output will given on tape 3 EXCLUSIVELY and/or the printer according to the following

Argument of WOT	Output on Tape 3	Output on Printer
1	yes	yes
2	yes	If SW3 down
3	yes	no
4	If SW3 up	yes
5	If SW3 up	If SW3 down
6	If SW3 up	no
7	no	yes
8	no	If SW3 down
9	no	no

This subroutine requires four other subroutines to be in the deck, viz., (LEV), (FIL), (SPH), and (STH).

msp

APPENDIX C. A Curve Fit for Transitional Nusselt Numbers

The treatment described was devised by R. T. Lancet and appeared originally in an internal General Electric Company report.

The form of the fitting equation chosen is given in equation (21) and repeated below.

$$\ln \eta = \frac{A}{N_{Re}} + B N_{Re} + C = \ln\left(\frac{N_{Nu}}{N_{Pr}^{\frac{1}{3}} N_{Re}}\right) \qquad \text{(C-1)}$$

As was discussed previously, the three coefficients are to be determined so that the Nusselt Numbers match at the boundaries of the transition region and so that the transitional Nusselt Number fairs smoothly into the turbulent value. The latter condition can be expressed for the present purposes as

$$\left.\frac{\partial\left[\ln\left(N_{Nu}/N_{Pr}^{\frac{1}{3}} N_{Re}\right)\right]}{\partial\left[\ln N_{Re}\right]}\right]_{transition} = \left.\frac{\partial\left[\ln\left(N_{Nu,T}/N_{Pr,T}^{\frac{1}{3}} N_{Re,T}\right)\right]}{\partial\left[\ln N_{Re,T}\right]}\right]_{transition} \qquad \text{(C-2)}$$

Using the form of the Nusselt Number correlation shown in equation (17) and introducing the symbol α for convenience, we can write

$$\alpha = \frac{N_{Nu,T}}{N_{Pr,T}^{\frac{1}{3}} N_{Re,T}} = a_T\, N_{Pr,T}^{(b_T - \frac{1}{3})} N_{Re}^{(c_T - 1)} \qquad \text{(C-3)}$$

Taking first the logarithm and then the derivative, there results

$$\ln \alpha = \ln a_T + (b_T - \tfrac{1}{3}) \ln N_{Pr,T} + (c_T - 1) \ln N_{Re,T} \qquad \text{(C-4)}$$

$$\frac{\partial \ln \alpha}{\partial \ln N_{Re,T}} = c_T - 1 \qquad \text{(C-5)}$$

Rewriting equation (C-1) for convenience and taking the derivative yields

$$\frac{\partial \ln \eta}{\partial \ln N_{Re}} = \frac{\partial}{\partial \ln N_{Re}}\left[\frac{A}{e^{\ln N_{Re,T}}} + B e^{\ln N_{Re,T}} + C\right]$$

$$= -\frac{A}{e^{\ln N_{Re,T}}} + B e^{\ln N_{Re,T}} = -\frac{A}{N_{Re}} + B N_{Re} \qquad \text{(C-6)}$$

Equating (C-5) and (C-6) yields one of the necessary algebraic equations,

$$-\frac{A}{N_{Re_1}} + B N_{Re_1} = c_T - 1 \qquad \text{(C-7a)}$$

Direct substitution of the transition Reynolds Numbers into equation (C-1) yields the other two algebraic equations,

$$\ln \eta_o = \frac{A}{N_{Re\,o}} + B\, N_{Re\,o} + C \qquad \text{(C-7b)}$$

$$\ln \eta_1 = \frac{A}{N_{Re\,1}} + B\, N_{Re\,1} + C \qquad \text{(C-7c)}$$

The solution of equations (C-7) for the coefficients A, B, and C yields the values given in equation (22).

```
* * * * * * * * * * * * * * * * * * * * * * * * *
* GENERAL FLOW PASSAGE (ANP 663)  COMPLETE SOURCE DECK  4/28/61
*GFP 663  GENERAL FLOW PASSAGE
*  A PROGRAM TO CALCULATE ONE-DIMENSIONAL COMPRESSIBLE
*  PRESSURE DROP AND SURFACE TEMPERATURES
*
*    S C SKIRVIN
*HAS AUTOMATIC CALCULATION OPTIONS CONTROLLED BY AVAIL-
*  ABLE INPUT DATA - WT FLOW ITERATED TO SATISFY
*  TWMAX OR EXIT PRES
*
*BEGIN STORAGE MAP
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
      EQUIVALENCE(PRTSUM,BG0(49)),(DEAD,BG0(13)),(KALCNO,BG0(27)),
     1(NOPRT,BG0(46)),(NOINPT,BG0(66))
     2,(MORCAS,BG0(41))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE(HEADER,HEDDUM(12))
      EQUIVALENCE(HEDDUM,BG1(974))
*END OF STORAGE MAP
*
      CALL WOT(5)
      CALL HDING(HEADER)
*IS THIS FIRST ENTRY
      IF(KFIRST-9999)90,80,90
*NOT FIRST ENTRY - IS SL 1 ON
   80 IF(SENSE LIGHT 1)82,84
*NORMAL SR ERROR RETURN
   82 DEAD=1.
      GO TO 300
*REASON FOR SECOND ENTRY NOT KNOWN
   84 CALL NETERR(99,99)
      GO TO 82
*NORMAL FIRST ENTRY
   90 KFIRST=9999
*TURN SENSE LIGHTS OFF
      SENSE LIGHT 0
*PERFORMS PRE-LOAD INITIALIZATION
  100 CALL INITAL
*
*READS INPUT DATA
  300 CALL READIN
```

```
*IS A SUMMARY PRINT WANTED
      IF(PRTSUM)400,400,900
*NORMAL SEQUENCE - PROCESS INPUT DATA
  400 CALL DATPRO
*CHECK INPUT CONSISTENCY AND ADEQUACY
  500 CALL CONSIS
*CHECK IF ERROR FOUND
      IF(DEAD)600,560,600
*CHECK IF FIRST CALC
  560 IF(KALCNO)600,600,570
*IS ALL PRINTOUT TO BE SUPPRESSED
  570 IF(NOPRT)580,580,700
*IS INPUT PRINTOUT TO BE SUPPRESSED
  580 IF(NOINPT)600,600,700
*PRINT INPUT DATA
  600 CALL INPPRT
*WAS AN ERROR FOUND
      IF(DEAD)700,700,300
*CARRY OUT CALCULATION OPTION
  700 CALL ITRCON
*DID ITERATION FAIL
      IF(SENSE LIGHT 2)710,760
  710 SENSE LIGHT 2
      IF(MORCAS)760,800,760
*IS PRINTOUT COMPLETELY SUPPRESSED
  760 IF(NOPRT)800,800,860
*PRINT RESULTS
  800 CALL OUTPUT
  860 IF(MORCAS)865,870,865
  865 KTPAR=KTPAR+1
      IF(KTOTPR-KTPAR)900,900,870
*IS THIS ONE-HUNDREDTH CALC
  870 IF(100-KALCNO)900,900,1000
*MAKE SUMMARY PRINTOUT
  900 CALL SUMPRT
*WAS THIS PRINTOUT A DIRECT REQUEST
      IF(PRTSUM)960,1000,960
  960 PRTSUM=0.
      GO TO 300
*IS THIS A PARAMETRIC CASE
 1000 IF(MORCAS)1010,1010,300
*RESET CALC DATA FIELDS WHERE NECESSARY FOR CHANGE CASE
 1010 CALL RESET
*RETURN FOR CHANGE CASE
      GO TO 300
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
*CONSIS  SR TO CHECK CONSISTENCY AND ADEQUACY OF
*  INPUT DATA AND SET CALCULATION OPTION FOR
*GFP 663  GENERAL FLOW PASSAGE
*  S C SKIRVIN
*
*    SETS DEAD=1. IF ANY ERROR FOUND, BUT ALWAYS
*    LOOKS FOR ALL ERRORS
      SUBROUTINE CONSIS
*
*BEGIN STORAGE MAP
```

```
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7          (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102   )),(BSI   ,BG1(202   )),
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224   )),(CLOSSI,BG1(237   )),
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438   )),(DHD   ,BG1(539   )),
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739   )),(DPARMI,BG1(747   )),
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759   )),(FMULTI,BG1(768   )),
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968   )),(HEDDUM,BG1(974   )),
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087  )),(KPARMR,BG1(1095  )),
     8(KRSCON,BG1(1103  )),(NDH   ,BG1(1107  )),(NAFL  ,BG1(1207  )),
```

```
     9(NLEN   ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(P0    ,BG1(2208 )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
     4(TEXI  ,BG1(2508 )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
     5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
*LIMITED USEAGE
      DIMENSION AFFD(100),DHD(100),OLEND(100),XOL(100)
      EQUIVALENCE(AFFD,AFF(2)),(CLOSSI,CLOSS(2)),(CLSMDI,CLSMOD(2)),
     1(DHD,DH(2)),(DH,DOUTER,ELPMAJ,WIDTH),(AFF,DINNER,ELPMIN,
     2HEIGHT),(FMULTI,FMULT(2)),(HMULTI,HMULT(2)),(ROUND,KRSCON),
     3(RECTNG,KRSCON(2)),(ELLIPS,KRSCON(3)),(RINGS,KRSCON(4)),
     4(OLEND,LENGTH(2)),(NRINGD,NORING(2)),(NAFF,NAFL),(THICKD,
     5THICK(2)),(PTIN,PIN),(TTIN,TIN),(PTEX,PEX),(TEX,TTEX),
     6(CASE,KASE),(CASTEP,KASTEP),(DHD,DHG),(DH,DHGSUB),(AFF,
     7AFFSUB),(OLEND,OL),(LENGTH,OLSUB),(ACCMNO,PER),(NOSTGE,MN),
     8(HTABI(4),A1),(FTABI(3),B1),(FTABI(4),OM),(FMULTI,AKF),(HMULTI,
     9AKH),(CIN,C1),(CEX,C2),(PHISUM,A2),(PHIEX,Q),(NLEN,NOL)
      EQUIVALE*CE(NDH,NDHG),(MAXMNO,OMAXD)
*ALL MODIFIED OFF-DESIGN(ANP 443) INPUT VARIABLES
*  ARE IN DIP LIST, FUNCTIONALLY WHEREVER POSSIBLE
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
```

```
     1BG(5474)                                                          0223 663
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))   0224 663
      COMMON BG                                                         0225 663
* * * END OF MASTER GROUPING                                            0226 663
      DIMENSION KOPSET(3,13),BSOD(8)                                    0227 663
      TABLE KOPSET(1,4,8, 1,4,3, 1,5,8, 1,5,3, 1,6,8, 1,6,3,            0228 663
     17,5,8, 7,5,3, 7,6,8, 7,6,3, 7,1,8, 7,1,3, 1,8,3)                  0229 663
*END OF STORAGE MAP                                                     0230 663
*                                                                       0231 663
      NOSTGE=NOSTGE                                                     0232 663
*IS THIS A PARAMETRIC STUDY                                             0233 663
      IF(MORCAS)90,90,80                                                0234 663
*IS THIS FIRST PARAMETRIC PASS                                          0235 663
   80 IF(FSTPAR)1080,1080,90                                            0236 663
*EITHER NON-PARAM OR FIRST PASS                                         0237 663
   90 CONTINUE                                                          0238 663
*CHECK XOL STAGE LENGTH INPUT                                           0239 663
      IF(TOTLEN)100,170,100                                             0240 663
  100 NOXOL=1                                                           0241 663
      DO 130 N=2,NOSTGE                                                 0242 663
      IF(XOL(N)-XOL(N-1))110,130,120                                    0243 663
  110 CALL NETERR(108,N)                                                0244 663
      DEAD=1.                                                           0245 663
      GO TO 130                                                         0246 663
  120 NOXOL=0                                                           0247 663
  130 CONTINUE                                                          0248 663
      IF(NOXOL)140,150,140                                              0249 663
  140 CALL NETERR(108,0)                                                0250 663
      DEAD=1.                                                           0251 663
  150 IF(XOL(NOSTGE) 1.)160,170,160                                     0252 663
  160 CALL NETERR(109,0)                                                0253 663
      DEAD=1.                                                           0254 663
  170 CONTINUE                                                          0255 663
*CHECK FOR SUFFICIENT DATA                                              0256 663
  440 DO 530 N=1,NOSTGE                                                 0257 663
      IF(CLENI(N))490,490,450                                           0258 663
  450 IF(DHI(N))460,460,470                                             0259 663
  460 CALL NETERR(N,1)                                                  0260 663
      DEAD=1.                                                           0261 663
  470 IF(AFFI(N))480,480,530                                            0262 663
  480 CALL NETERR(N,2)                                                  0263 663
      DEAD=1.                                                           0264 663
  490 IF(AFFI(N))520,520,530                                            0265 663
  520 CALL NETERR(N,3)                                                  0266 663
  530 CONTINUE                                                          0267 663
      IF(PIND-PEXD)550,545,550                                          0268 663
*NO PRES DROP CALC                                                      0269 663
  545 NSKPPR=1                                                          0270 663
      GO TO 580                                                         0271 663
  550 NSKPPR=0                                                          0272 663
  555 DO 570 M=1,4                                                      0273 663
      IF(FTABI(M))570,560,570                                           0274 663
  560 CALL NETERR(102,M)                                                0275 663
      DEAD=1.                                                           0276 663
  570 CONTINUE                                                          0277 663
  580 IF(TIND-TEXD)590,585,590                                          0278 663
*NO HEAT TRANSFER SIGNAL                                                0279 663
```

```
 585 NSKPHT=1
     GO TO 600
 590 NSKPHT=0
 600 IF(HTABI(1))620,610,620
 610 CALL NETERR(103,1)
     DEAD=1.
 620 IF(HTABI(4))640,630,640
 630 CALL NETERR(103,4)
     DEAD=1.
 640 CONTINUE
 650 IF(NSKPPR*NSKPHT)660,670,660
NEITHER HEAT TRANSFER NOR PRESSURE DROP REQUIRED
 660 CALL NETERR(104,104)
     DEAD=1.
 670 IF(ENTRNC)720,720,680
 680 ENTRN=1.
     IF(BETA1)700,690,700
 690 CALL NETERR(105,105)
 700 IF(BETA2)720,710,720
 710 CALL NETERR(106,106)
CHECK FOR QBAR INPUT
 720 IF(QOQBAR)722,726,722
 722 IF(QBAR)724,726,724
 724 QTOTD=QOQBAR*QBAR
     QTOT=QTOTD
CONSISTENCY AND ADEQUACY CHECKING FINISHED
 726 CONTINUE
     IF(NSKPPR)980,730,980
 730 IF(NSKPHT)980,740,980
SET OPTION INDICATOR
 740 KOPT=0
     DO 741 L=1,8
 741 BSOD(L)=BSI(L)
     IF(PSEX)742,742,744
 742 IF(PSXOPI)744,744,743
 743 BSOD(5)=1.
 744 IF(PEX)745,745,747
 745 IF(PTXOPI)747,747,746
 746 BSOD(6)=1.
 747 IF(TEX)750,748,750
 748 IF(TEXOTI)750,750,749
 749 BSOD(3)=1.
 750 DO 760 J=1,13
     DO 752 I=1,3
     ID=KOPSET(I,J)
     IF(BSOD(ID))752,760,752
 752 CONTINUE
NORMAL EXIT SETS OPTION
     KOPT=J
     KOPTH=10-KOPT
     GO TO 900
 760 CONTINUE
NORMAL EXIT MEANS OPTION CANNOT BE SET
 790 CALL NETERR(150,1)
     SENSE LIGHT 3
     DEAD=1.
 900 CONTINUE
```

```
*OPTION INDICATOR PROCESSING FINISHED
  980 CONTINUE
*IS POWER PROFILE PRESENT IF NEEDED
      IF(KPOW)1080,1040,1080
 1040 IF(NSKPHT)1080,1050,1080
 1050 CALL NETERR(151,1)
      DEAD=1.
 1080 CONTINUE
*FINISHED
      RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
*DATPRO  SR TO PROCESS INPUT DATA FOR
*GFP 663  GENERAL FLOW PASSAGE
*    S C SKIRVIN
*
      SUBROUTINE DATPRO
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1    )),(ACCMNO,BG0(2    )),(ACCPRS,BG0(3    )),
     2(ACCTMP,BG0(4    )),(ALLRUN,BG0(5    )),(AUTOLS,BG0(6    )),
     3(BD    ,BG0(7    )),(BLANKS,BG0(8    )),(BETA1 ,BG0(9    )),
     4(BETA2 ,BG0(10   )),(CIN   ,BG0(11   )),(CEX   ,BG0(12   )),
     5(DEAD  ,BG0(13   )),(DELH  ,BG0(14   )),(DERIV ,BG0(15   )),
     6(ENTRN ,BG0(16   )),(ENTRNC,BG0(17   )),(FD    ,BG0(18   )),
     7(FTIN  ,BG0(19   )),(FTOUT ,BG0(20   )),(FSTPAR,BG0(21   )),
     8(GOAL  ,BG0(22   )),(GAS   ,BG0(23   )),(HIN   ,BG0(24   )),
     9(ITRY  ,BG0(25   )),(KTRCRD,BG0(26   )),(KALCNO,BG0(27   ))
      EQUIVALENCE
     1(KTCHAD,BG0(28   )),(KTWADJ,BG0(29   )),(KTCHTO,BG0(30   )),
     2(KPOW  ,BG0(31   )),(KOPT  ,BG0(32   )),(KOSCIL,BG0(33   )),
     3(KCHOKE,BG0(34   )),(KASE  ,BG0(35   )),(KASTEP,BG0(36   )),
     4(LOC   ,BG0(37   )),(LIMCHK,BG0(38   )),(LMCHTO,BG0(39   )),
     5(LIMTRY,BG0(40   )),(MORCAS,BG0(41   )),(NSKPPR,BG0(42   )),
     6(NSKPHT,BG0(43   )),(NT    ,BG0(44   )),(NHOT  ,BG0(45   )),
     7(NOPRT ,BG0(46   )),(NOSTGE,BG0(47   )),(PARPRT,BG0(48   )),
     8(PRTSUM,BG0(49   )),(RNKIN ,BG0(50   )),(RNKOUT,BG0(51   )),
     9(SVACMN,BG0(52   )),(SVACPR,BG0(53   )),(TOTLND,BG0(54   ))
      EQUIVALENCE
     1(TRY0  ,BG0(55   )),(TRY1  ,BG0(56   )),(TRY2  ,BG0(57   )),
     2(TRY3  ,BG0(58   )),(TEST1 ,BG0(59   )),(TOTLEN,BG0(60   )),
     3(WHI   ,BG0(61   )),(WLO   ,BG0(62   )),(YIELD0,BG0(63   )),
     4(YIELD1,BG0(64   )),(YIELD2,BG0(65   )),(NOINPT,BG0(66   )),
```

```
     5(LIMPRS,BGO(67    )),(PRTALL,BGO(68    )),(OMAXD ,BGO(69    )),
     6(OMAX,BGO(70)),(OMAX1,BGO(71)),(KOPTH,BGO(72)),
     7          (DMCONVTBGO( 5)DT(KD+,B+0(76D4
     878)),(MAXTMP,BGO(79)),(LMBULK,BGO(80)),(TBBULK,BGO(81)),
     9(KCHK1,BGO(1)),(KCHK2,BGO(7)),(KCHK3,BGO(18)),(KGAS,BGO(82))
      EQUIVALENCE(PDYIN,BGO(73)),(PDYEX,BGO(74)),(OMINLT,BGO(83)),
     1(OMEXIT,BGO(84)),(DPIN,BGO(85)),(DPEX,BGO(86))
     2,(TRANSF,BGO(87)),(TRANHL,BGO(88)),(TRANHU,BGO(89))
     3,(NEWSET,BGO(90)),(KTPAR,BGO(91)),(KTOTPR,BGO(92)),(QBAR,BGO(93)),
     4(QOQBAR,BGO(94)),(NOGEOM,BGO(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2      )),(AFFI  ,BG1(102   )),(BSI   ,BG1(202   )),
     2(BSO   ,BG1(213    )),(BHIGH ,BG1(224   )),(CLOSSI,BG1(237   )),
     3(CLSGEN,BG1(337    )),(CLSMDI,BG1(438   )),(DHD   ,BG1(539   )),
     4(DHI   ,BG1(639    )),(DPARAM,BG1(739   )),(DPARMI,BG1(747   )),
     5(FTABI ,BG1(755    )),(FPARMI,BG1(759   )),(FMULTI,BG1(768   )),
     6(GMASS ,BG1(868    )),(HTABI ,BG1(968   )),(HEDDUM,BG1(974   )),
     7(HMULTI,BG1(987    )),(KPARAM,BG1(1087  )),(KPARMR,BG1(1095  )),
     8(KRSCON,BG1(1103   )),(NDH   ,BG1(1107  )),(NAFL  ,BG1(1207  )),
     9(NLEN  ,BG1(1307   )),(NCLOSS,BG1(1407  )),(NCLSMD,BG1(1507  ))
      EQUIVALENCE
     1(NHMULT,BG1(1607   )),(NFMULT,BG1(1707  )),(OLEND ,BG1(1808  )),
     2(OLENI ,BG1(1908   )),(PHISUM,BG1(2008  )),(PHIEX ,BG1(2108  )),
     3(PO    ,BG1(2208   )),(P1    ,BG1(2308  )),(P2    ,BG1(2408  )),
     4(TEXI  ,BG1(2508   )),(TW    ,BG1(2608  )),(XOLD  ,BG1(2708  )),
     5(XOL   ,BG1(2808   )),(REYNO ,BG1(2908  )),(FRIC  ,BG1(3008  )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
```

```
*
*LIMITED USEAGE
      DIMENSION AFFD(100),DHD(100),OLEND(100),XOL(100)
      EQUIVALENCE(AFFD,AFF(2)),(CLOSSI,CLOSS(2)),(CLSMDI,CLSMOD(2)),
     1(DHD,DH(2)),(DH,DOUTER,ELPMAJ,WIDTH),(AFF,DINNER,ELPMIN,
     2HEIGHT),(FMULTI,FMULT(2)),(HMULTI,HMULT(2)),(ROUND,KRSCON),
     3(RECTNG,KRSCON(2)),(ELLIPS,KRSCON(3)),(RINGS,KRSCON(4)),
     4(OLEND,LENGTH(2)),(NRINGD,NORING(2)),(NAFF,NAFL),(THICKD,
     5THICK(2)),(PTIN,PIN),(TTIN,TIN),(PTEX,PEX),(TEX,TTEX),
     6(CASE,KASE),(CASTEP,KASTEP),(DHD,DHG),(DH,DHGSUB),(AFF,
     7AFFSUB),(OLEND,OL),(LENGTH,OLSUB),(ACCMNO,PER),(NOSTGE,MN),
     8(HTABI(4),A1),(FTABI(3),B1),(FTABI(4),OM),(FMULTI,AKF),(HMULTI,
     9AKH),(CIN,C1),(CEX,C2),(PHISUM,A2),(PHIEX,Q),(NLEN,NOL)
      EQUIVALENCE(NDH,NDHG),(MAXMNO,OMAXD)
*ALL MODIFIED OFF-DESIGN(ANP 443) INPUT VARIABLES
*  ARE IN DIP LIST, FUNCTIONALLY WHEREVER POSSIBLE
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*END OF STORAGE MAP
*
*IS THIS A PARAMETRIC STUDY
      IF(MORCAS)90,90,80
*IS THIS FIRST PARAMETRIC CASE
   80 IF(FSTPAR)1080,1080,90
*EITHER NON-PARAM OR FIRST PASS
   90 CONTINUE
*TRANSFER FROM INPUT TO PERM TABLES
      CALL DSTRB1(BSI,11,BSO,0,0,KSIG)
*
*CHECK CROSS SECTION OPTIONS
      DO 110 ND=1,4
      ND=ND
      IF(KRSCON(ND))140,110,140
  110 CONTINUE
*NO OPTION EXERCISED
      KRT=1
  115 CALL DSTRB1(DHD,NOSTGE,DHI,0,0,KSIG)
  120 CALL DSTRB1(DHI,NOSTGE,DHI,NDH,2,KSIG)
      GO TO(125,150),KRT
  125 CALL DSTRB1(AFFD,NOSTGE,AFFI,0,0,KSIG)
  130 CALL DSTRB1(AFFI,NOSTGE,AFFI,NAFL,2,KSIG)
      GO TO 225
*CROSS SECTION OPTION PROCESSING
  140 IF(ND-1)145,145,150
*ROUND
  145 KRT=2
      GO TO 115
*GENERAL
  150 DO 210 N=1,NOSTGE
      IF(ND-1)155,155,165
*ROUND
  155 IF(DHI(N))210,210,160
```

```
  160 AFFI(N)=.7854*DHI(N)**2
      GO TO 210
*GENERAL
  165 IF(DHD(N))170,170,167
  167 DHDLOC=DHD(N)
*
*BACKSPACING SECTION
  170 K1=0
      K2=0
      K3=0
      DO 190 K=1,N
      KD=N K+1
      IF(K1)172,172,176
*GENERAL
  172 IF(AFFD(KD))176,176,174
  174 AFFLOC=AFFD(KD)
      K1=1
*SPECIFIC
  176 IF(3 ND)178,190,190
*CONCENTRIC
  178 IF(K2)180,180,184
*THICKNESS
  180 IF(THICKD(KD))184,184,182
  182 THKLOC=THICKD(KD)
      K2=1
  184 IF(K3)186,186,190
*NO OF RINGS
  186 IF(NRINGD(KD))190,190,188
  188 FRINGS=FLOATF(NRINGD(KD))
      K3=1
  190 CONTINUE
*BACKSPACING FINISHED
*
*SPECIFIC
      IF(ND-3)195,200,205
*RECTANGULAR
  195 AFFI(N)=DHDLOC*AFFLOC
      DHI(N)=2.*AFFI(N)/(DHDLOC+AFFLOC)
      GO TO 210
*ELLIPTICAL
  200 AFFI(N)=.7854*DHDLOC*AFFLOC
      DHI(N)=1.80063*AFFI(N)/SQRTF(DHDLOC**2+AFFLOC**2)
      GO TO 210
*CONCENTRIC RINGS
  205 DHI(N)=((DHDLOC-AFFLOC)/(FRINGS-1.))-2.*THKLOC
      AFFI(N)=.3927*FRINGS*DHI(N)*(DHDLOC+AFFLOC)
  210 CONTINUE
  225 CONTINUE
*FINISHED WITH CROSS SECTION OPTIONS
*
*X/L STAGE LENGTH OPTION
  250 IF(TOTLEN)251,255,251
*X/L STAGE LENGTHS LENGTHS LOADED
  251 DO 254 N=1,NOSTGE
      IF(N 1)252,252,253
  252 OLENI(N)=XOL(N)*TOTLEN
      GO TO 254
```

```
  253 OLENI(N)=(XOL(N)-XOL(N-1))*TOTLEN
  254 CONTINUE
      TOTLND=TOTLEN
      CALL DSTRB1(XOL,NOSTGE,XOLD,0,0,KSIG)
      GO TO 258
*STAGE LENGTHS LOADED
  255 CALL DSTRB1(OLEND,NOSTGE,OLENI,0,0,KSIG)
      CALL DSTRB1(OLENI,NOSTGE,OLENI,NLEN,2,KSIG)
      TOTLND=0.
      DO 256 N=1,NOSTGE
  256 TOTLND=TOTLND+OLENI(N)
      SUMLEN=0.
      DO 257 N=1,NOSTGE
      SUMLEN=SUMLEN+OLENI(N)
      XOLD(N)=SUMLEN/TOTLND
  257 CONTINUE
*STAGE LENGTH PROCESSING FINISHED
  258 CONTINUE
*INTERSTAGE LOSS COEFFICIENTS
      CALL DSTRB1(CLSMDI,NOSTGE,CLSMDI,NCLSMD,2,KSIG)
      CALL DSTRB1(CLOSSI,NOSTGE,CLOSSI,NCLOSS,2,KSIG)
*CHECK PRES RATIO INPUT
      IF(PIN)266,266,260
  260 IF(PEX)266,261,263
  261 IF(PTXOPI)266,263,262
  262 PEXD=PIN*PTXOPI
  263 IF(PSEX)266,264,266
  264 IF(PSXOPI)266,266,265
  265 PSEXD=PIN*PSXOPI
  266 CONTINUE
*CHECK NEED FOR UNIT CHANGES
      IF(FTIN)268,310,268
*CHECK FOR LENGTH UNIT CHANGE DELAY
  268 IF(NOINPT)270,269,270
  269 IF(PARPRT)270,274,270
  270 DO 272 N=1,NOSTGE
      DHI(N)=DHI(N)*12.
      OLENI(N)=OLENI(N)*12.
      AFFI(N)=AFFI(N)*144.
  272 CONTINUE
      TOTLND=TOTLND*12.
  274 PEXD=PEXD/144.
      PIND=PIND/144.
      PSEXD=PSEXD/144.
  310 IF(RNKIN)400,320,400
  320 CALL CONTMP(GRTMPI,3,GRTMPO,1)
  400 CONTINUE
*CHECK TEMP RATIO INPUT
      IF(TIN)440,440,425
  425 IF(TEX)440,430,440
  430 IF(TEXOTI)440,440,435
  435 TEXD=TIND*TEXOTI
*CHECK FOR QBAR INPUT
  440 IF(QOQBAR)450,470,450
  450 IF(QBAR)460,470,460
  460 QTOTD=QOQBAR*QBAR
      QTOT=QTOTD
```

```
  470 CONTINUE
*AUTOMATIC DISTRIBUTION OF STAGE LENGTH
      IF(OLEND(1))500,580,500
*ARE DOWNSTREAM STAGE LENGTHS ZERO
  500 DO 510 N=2,NOSTGE
      IF(CLEND(N))510,510,580
  510 CONTINUE
*IS ANY DISTRIBUTION SUPPLIED
      IF(NLEN(1))520,520,580
  520 DO 570 N=2,NOSTGE
*IS AN EXIT LOSS COEFFICIENT PROVIDED
  530 IF(CLOSSI(N))570,540,570
*CAN LOSS COEFFICIENT BE CALCULATED
  540 IF(AUTOLS)550,560,550
*IS THERE AN AREA CHANGE
  550 IF(AFFI(N)-AFFI(N-1))570,560,570
*SUPPLY STAGE LENGTH
  560 OLENI(N)=OLEND(1)
  570 CONTINUE
  580 CONTINUE
*PROCESS POWER PROFILE
      KPOW=0
      DO 1030 N=1,NOSTGE
      IF(PO(N))990,990,1060
  990 IF(P1(N))1000,1000,1060
 1000 IF(P2(N))1010,1010,1060
 1010 IF(PHISUM(N))1030,1030,1020
 1020 KPOW=1
 1030 CONTINUE
      GO TO 1080
*INTEGRATE TABULAR PROFILE
 1060 CALL POWER3(PHIEX,PHISUM,NOSTGE,OLENI,PO,P1,P2)
      KPOW=1
 1080 CONTINUE
*PROCESSING FINISHED
      RETURN
      END(0,1,0)
 * * * * * * * * * * * * * * * * * * * * * * * *
*DPFRLT   A SR TO CALCULATE PRESS DROP FOR LALMINAR OR TURBULENT FLOW
*  WITH OR WITHOUT ENTRANCE LENGTH EFFECTS
*GFP 663  GENERAL FLOW PASSAGE
*  S C SKIRVIN
USEAGE - CALL DPFRLT(IDENTIFICATION WANTED(=1 IF YES))

      SUBROUTINE DPFRLT(IDENT)

BEGIN STORAGE MAP
GENERAL USEAGE
      DIMENSION
     1AFFI   (100 ),BSI    (11  ),BSO    (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI    (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH    (100 ),NAFL   (100 ),NLEN   (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),PO     (100 ),P1     (100 ),
     7P2     (100 ),THICKD(100 ),TEXI   (100 ),XOLD   (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW     (100 ),REYNO (100 ),FRIC  (100 ),
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     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7            (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102   )),(BSI   ,BG1(202   )),
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224   )),(CLOSSI,BG1(237   )),
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438   )),(DHD   ,BG1(539   )),
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739   )),(DPARMI,BG1(747   )),
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759   )),(FMULTI,BG1(768   )),
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968   )),(HEDDUM,BG1(974   )),
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087  )),(KPARMR,BG1(1095  )),
     8(KRSCON,BG1(1103  )),(NDH   ,BG1(1107  )),(NAFL  ,BG1(1207  )),
     9(NLEN  ,BG1(1307  )),(NCLOSS,BG1(1407  )),(NCLSMD,BG1(1507  ))
      EQUIVALENCE
     1(NHMULT,BG1(1607  )),(NFMULT,BG1(1707  )),(OLEND ,BG1(1808  )),
     2(OLENI ,BG1(1908  )),(PHISUM,BG1(2008  )),(PHIEX ,BG1(2108  )),
     3(P0    ,BG1(2208  )),(P1    ,BG1(2308  )),(P2    ,BG1(2408  )),
     4(TEXI  ,BG1(2508  )),(TW    ,BG1(2608  )),(XOLD  ,BG1(2708  )),
     5(XOL   ,BG1(2808  )),(REYNO ,BG1(2908  )),(FRIC  ,BG1(3008  )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
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1.75

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*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,FTABI(3)),
     1(EXPFTB,FTABI(4)),(ND,NOSTGE),(G,GMASS),(REAVG,REYNO),
     2(OMEX,OMEXI)
      DIMENSION G(100),REAVG(100),OMEX(100)
*END OF STORAGE MAP
*
      ND=NOSTGE
*IS IDENTIFICATION REQUESTED
      IF(IDENT)95,95,90
   90 PRINT 32000
32000 FORMAT
      SPACE 2
 * * THE PRES DROP SR (DPFRLT) IS BASED ON THE OFF DESIGN * *
 * *         ANALYSIS AND REQUIRES UPSTREAM PRESSURES        * *
      END OF FORMAT
      GO TO 96
*
   95 CONTINUE
*INITIALIZATION
      KCHOKE=0
```

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      SUMLEN=0.
      OMAX=0.
*STAGE BY STAGE
   96 DO 820 N=1,ND
      KTPRS=1
*WAS IDENTIFICATION REQUESTED
      IF(IDENT)98,98,200
*NORMAL SEQUENCING
*FIRST STAGE ONLY
   98 IF(N 1)100,100,120
  100 OMIN=AMACH(.1,G(1),PIND,TIND,ACCMNO,GAS)
      OMINLT=OMIN
      OMAX=MAX1F(OMAX,OMIN)
      IF(.9-OMIN)10000,10000,102
  102 PDYIN=DYPRS(G(1),PIND,TIND,OMIN,GAS)
*CHECK ENTRANCE LOSS
      IF(CIN)106,104,106
  104 PINI=PIND
      DPIN=0.
      GO TO 108
  106 DPIN=CIN*PDYIN
      PINI=PIND-DPIN
      OMIN=AMACH(OMIN,G(1),PINI,TIND,ACCMNO,GAS)
      OMAX=MAX1F(OMAX,OMIN)
      IF(.9-OMIN)10000,10000,108
  108 TINI=TIND
      GO TO 130
*SUBSEQUENT STAGES ONLY
  120 OMIN=AMACH(OMEXI(N),G(N),PINI,TINI,ACCMNO,GAS)
      OMAX=MAX1F(OMAX,OMIN)
      IF(.9-OMIN)10000,10000,130
*ALL STAGES
  130 CONTINUE
      IF(OLENI(N))132,132,133
  132 PEXI(N)=PINI
      FRIC(N)=0.0
      GO TO 740
  133 IF(DHI(N))134,134,136
  134 REAVG(N)=0.
      GO TO 132
  136 OMEX1=1.05*OMIN
      IF(.9-OMEX1)140,140,150
  140 OMEX1=.899
  150 OMAVG=(OMEX1+OMIN)/2.
      TAVG=(TEXI(N)+TINI)/2.
      REAVG(N)=G(N)*DHI(N)*12./VISC(TAVG,GAS)
      SUMLEN=SUMLEN+OLENI(N)
*OBTAIN FRICTION FACTOR
  200 FRIC(N)=FRCFAC(REAVG(N),DHI(N),SUMLEN,COFFLM,EXPFLM,
     1COFFTB,EXPFTB,BETA1,BETA2,ENTRNC,IDENT)
     2*FMULTI(N)
*WAS IDENTIFICATION REQUESTED
      IF(IDENT)210,210,860
*NORMAL CONTINUATION
  210 CONTINUE
      PBARN=PINI
      COFMAC=-(GAM(TAVG,GAS)/2.)*
```

```
    1(LOGF(TEXI(N)/TINI)+(4.*FRIC(N)*OLENI(N)/DHI(N)))
  680 PEXI(N)=PINI*EXPF(COFMAC*OMAVG**2)
      OMEX(N)=AMACH(OMEX1,G(N),PEXI(N),TEXI(N),ACCMNO,GAS)
      OMAX=MAX1F(OMAX,OMEX(N))
      IF(.9-OMEX(N))10000,10000,700
10000 KCHOKE=N
      GO TO 890
  700 IF(ABSF((PEXI(N)-PBARN)/PEXI(N))-ACCPRS)740,740,710
*HAS COUNTER LIMIT BEEN EXCEEDED
  710 IF(LIMPRS-KTPRS)720,730,730
  720 CALL NETERR(180,N)
      SENSE LIGHT 2
      GO TO 890
  730 KTPRS=KTPRS+1
      OMAVG=(OMIN+OMEX(N))/2.
      OMEX1=OMEX(N)
      PBARN=PEXI(N)
      GO TO 680
*CALC EXIT DYNAMIC PRESSURE
  740 PDYEXI(N)=DYPRS(G(N),PEXI(N),TEXI(N),OMEX(N),GAS)
*IS THIS THE LAST STAGE
      IF(ND-N)780,780,750
*IS AUTO LOSS CALC WANTED
  750 IF(AUTOLS)780,780,755
*DOES AREA CHANGE
  755 IF(AFFI(N)/AFFI(N+1)-1.)757,780,756
  756 KLOSS=1
      GO TO 760
  757 KLOSS=3
*IS AUTO LOSS MODIFIER DIFFERENT THAN ZERO
  760 IF(CLSMDI(N))765,780,765
*CALC AUTO LOSS COEFF
  765 CALL LOSS(AFFI(N),AFFI(N 1),KLOSS,OMEX(N),DUM1,DUM2,
    1DUM3,CLSGEN(N))
      DPINT(N)=CLSGEN(N)*CLSMDI(N)*PDYEXI(N)
      GO TO 810
*REGULAR INTERSTAGE LOSS CALC
  780 IF(CLOSSI(N))790,800,790
  790 DPINT(N)=CLOSSI(N)*PDYEXI(N)
      GO TO 810
  800 DPINT(N)=0.
  810 PINI=PEXI(N)-DPINT(N)
      OMIN=OMEX(N)
      TINI=TEXI(N)
  820 CONTINUE
*STAGE-BY-STAGE CALCULATIONS FINISHED
*SET EXIT MACH NO
      IF(DPINT(ND))840,830,840
  830 OMEXIT=OMIN
      PDYEX=PDYEXI(ND)
      GO TO 850
  840 OMEXIT=AMACH(OMIN,G(ND),PINI,TINI,ACCMNO,GAS)
      PDYEX=DYPRS(G(ND),PINI,TINI,OMEXIT,GAS)
*EXIT STATIC PRESSURE
  850 PSEXD=PSTAT(PINI,TINI,OMEXIT,GAS)
*EXIT LOSS CALC
      IF(CEX)870,860,870
```

```
  860 DPEX=0.
      GO TO 880
  870 DPEX=CEX*PDYEX
  880 PEXD=PINI-DPEX
*SR FINISHED
  890 CONTINUE
      RETURN
      END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
CFRCFAC00A FUNCTION TO EVALUATE FRICTION FACTORS
*  FOR GFP(ANP 663)
*USEAGE - FRCFAC(REY NO, HYDR DIAM, DISTANCE FROM ENTRANCE,
*  COEFF LAM, EXP LAM, COEFF TURB, EXP TURB, LAM ENTRANCE
*  COEFF, TURB ENTRANCE COEFF, ENTRANCE EFFECT WANTED
*  (=1 IF YES), IDENTIFICATION WANTED(=1 IF YES))
      FUNCTION FRCFAC(REYNO,DH,SUMLEN,COFFLM,EXPFLM,
     1COFFTB,EXPFTB,BETA1,BETA2,ENTRN,IDENT)
*BEGIN STORAGE MAP
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
      EQUIVALENCE(TRANSF,BG0(87)),(TRANHL,BG0(89)),(TRANHU,BG0(90))
*END OF STORAGE MAP
*IS IDENTIFICATION REQUESTED
      IF(IDENT)120,120,100
  100 PRINT 32000
32000 FORMAT
      SPACE 2
 * * THE LENGTH-DEPENDENT FRICTION FACTOR * *
 * *  IS CALCULATED FROM                   * *
 * F.F.=F.F.(INF)*(1 BETA1*N(RE)*(DH/LEN)) (N(RE) LESS OR = 2300)
 * F.F.=F.F.(INF)*(1 BETA2*(DH/LEN)) (N(RE) MORE THAN 2300)
      END OF FORMAT
      GO TO 190
*TRANSITION TEST
  120 IF(REYNO)122,122,124
  122 FRCFAC=0.
      GO TO 190
  124 IF(REYNO-TRANSF)130,130,160
*LAMINAR
  130 FRCFAC=COFFLM*REYNO**EXPFLM
*IS ENTRANCE LENGTH EFFECT REQUESTED
      IF(ENTRN)190,190,140
*IS LENGTH FACTOR PRESENT
  140 IF(BETA1)150,190,150
*CALC ENTRANCE EFFECT
  150 FRCFAC=FRCFAC*(1.+(BETA1*REYNO*DH/SUMLEN))
      GO TO 190
*TURBULENT
  160 FRCFAC=COFFTB*REYNO**EXPFTB
*IS ENTRANCE LENGTH EFFECT REQUESTED
      IF(ENTRN)190,190,170
*IS LENGTH FACTOR PRESENT
  170 IF(BETA2)180,190,180
```

```
*CALC ENTRN EFFECT
  180 FRCFAC=FRCFAC*(1.+BETA2*DH/SUMLEN)
*FINISHED
  190 CONTINUE
      RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
*INITAL  SR TO PERFORM PRE-LOAD INITIALIZATION FOR
*GFP 663  GENERAL FLOW PASSAGE
*    S C SKIRVIN
*
      SUBROUTINE INITAL
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),PO    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BGO NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BGO(1    )),(ACCMNO,BGO(2    )),(ACCPRS,BGO(3    )),
     2(ACCTMP,BGO(4    )),(ALLRUN,BGO(5    )),(AUTOLS,BGO(6    )),
     3(BD    ,BGO(7    )),(BLANKS,BGO(8    )),(BETA1 ,BGO(9    )),
     4(BETA2 ,BGO(10   )),(CIN   ,BGO(11   )),(CEX   ,BGO(12   )),
     5(DEAD  ,BGO(13   )),(DELH  ,BGO(14   )),(DERIV ,BGO(15   )),
     6(ENTRN ,BGO(16   )),(ENTRNC,BGO(17   )),(FD    ,BGO(18   )),
     7(FTIN  ,BGO(19   )),(FTOUT ,BGO(20   )),(FSTPAR,BGO(21   )),
     8(GOAL  ,BGO(22   )),(GAS   ,BGO(23   )),(HIN   ,BGO(24   )),
     9(ITRY  ,BGO(25   )),(KTRCRD,BGO(26   )),(KALCNO,BGO(27   ))
      EQUIVALENCE
     1(KTCHAD,BGO(28   )),(KTWADJ,BGO(29   )),(KTCHTO,BGO(30   )),
     2(KPOW  ,BGO(31   )),(KOPT  ,BGO(32   )),(KOSCIL,BGO(33   )),
     3(KCHOKE,BGO(34   )),(KASE  ,BGO(35   )),(KASTEP,BGO(36   )),
     4(LOC   ,BGO(37   )),(LIMCHK,BGO(38   )),(LMCHTO,BGO(39   )),
     5(LIMTRY,BGO(40   )),(MORCAS,BGO(41   )),(NSKPPR,BGO(42   )),
     6(NSKPHT,BGO(43   )),(NT    ,BGO(44   )),(NHOT  ,BGO(45   )),
     7(NOPRT ,BGO(46   )),(NOSTGE,BGO(47   )),(PARPRT,BGO(48   )),
     8(PRTSUM,BGO(49   )),(RNKIN ,BGO(50   )),(RNKOUT,BGO(51   )),
     9(SVACMN,BGO(52   )),(SVACPR,BGO(53   )),(TOTLND,BGO(54   ))
      EQUIVALENCE
     1(TRYO  ,BGO(55   )),(TRY1  ,BGO(56   )),(TRY2  ,BGO(57   )),
     2(TRY3  ,BGO(58   )),(TEST1 ,BGO(59   )),(TOTLEN,BGO(60   )),
     3(WHI   ,BGO(61   )),(WLO   ,BGO(62   )),(YIELDO,BGO(63   )),
     4(YIELD1,BGO(64   )),(YIELD2,BGO(65   )),(NOINPT,BGO(66   )),
     5(LIMPRS,BGO(67   )),(PRTALL,BGO(68   )),(OMAXD ,BGO(69   )),
     6(OMAX,BGO(70)),(OMAX1,BGO(71)),(KOPTH,BGO(72)),
     7        (DMCONV,BGO(75)),(KDI,BGO(76)),(KDD,BGO(77)),(TRYMAX,BGO(
     878)),(MAXTMP,BGO(79)),(LMBULK,BGO(80)),(TBBULK,BGO(81)),
     9(KCHK1,BGO(1)),(KCHK2,BGO(7)),(KCHK3,BGO(18)),(KGAS,BGO(82))
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      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3                 ,(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102  )),(BSI   ,BG1(202  )),
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224  )),(CLOSSI,BG1(237  )),
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438  )),(DHD   ,BG1(539  )),
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739  )),(DPARMI,BG1(747  )),
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759  )),(FMULTI,BG1(768  )),
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968  )),(HEDDUM,BG1(974  )),
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087 )),(KPARMR,BG1(1095 )),
     8(KRSCON,BG1(1103  )),(NDH   ,BG1(1107 )),(NAFL  ,BG1(1207 )),
     9(NLEN  ,BG1(1307  )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607  )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908  )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(P0    ,BG1(2208  )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
     4(TEXI  ,BG1(2508  )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
     5(XOL   ,BG1(2808  )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
```

```
      COMMON BG
* * * END OF MASTER GROUPING
      EQUIVALENCE(HEADER,HEDDUM(12))
*FOR LOWER MEMORY IN INITAL
      DIMENSION KNOPTL(2,10),KNPARL(4,13),KSHIFT(72),KUP(72)
      DIMENSION PRTGSL(9)
      EQUIVALENCE(KSHIFT,KNOPTL),(KSHIFT(21),KNPARL),
     1(KUP,KONOPT),(KUP(21),KONPAR)
*HOLLERITH GROUPING
      DIMENSION BWHEN(2),BINCH(4),BFOOT(4),BUNLEN(4,2),
     2BUNTMP(2)
      DIMENSION BLOW(12)
      EQUIVALENCE(BWHEN,BHIGH),(BUNLEN,BHIGH(3)),(BUMTMP,
     1BHIGH(11))
*END OF STORAGE MAP
      TABLE KNOPTL(4,7, 4,7, 5,7, 5,7, 6,7, 6,7, 5,1, 5,1, 6,1,
     16,1),KNPARL(8,4,2,1, 3,4,2,1, 8,5,2,1, 3,5,2,1, 8,6,2,1,
     23,6,2,1, 8,7,5,2, 3,7,5,2, 8,7,2,6, 3,7,2,6, 8,7,2,1, 3,7,2,1,
     38,3,2,1)
     4,BLOW(72H INPUTOUTPUT INCHES, SQ. IN., PSIA,    FEET, SQ. FT., PSF
     5A, DEG F,DEG R,)
      TABLE PRTGSL(54HAIR   N2    CO2    H2    O2    HE    ARGON FREON NE
     1ON   )
*
      CALL NEWSET(1)
*DO OVERALL ZERO INITIALIZATION
      DO 100 L=1,5172
  100 BG(L)=0.
*NON-ZERO INITIALIZATION
*TRANSFER TO COMMON STORAGE
      DO 110 L=1,72
  110 KUP(L)=KSHIFT(L)
B     BLANKS=606060606060
      DO 120 L=1,12
      BHIGH(L)=BLOW(L)
  120 HEDDUM(L)=BLANKS
      DO 130 N=1,100
      CLSMDI(N)=1.
      FMULTI(N)=1.
      HMULTI(N)=1.
  130 CONTINUE
      DO 140 L=1,9
  140 PRTGAS(L)=PRTGSL(L)
*
      ACCMNO=1.E-4
      ACCPRS=1.E-4
      ACCTMP=.049
      GAS=1.
      KASE=1
      KASTEP=1
      LIMCHK=10
      LIMPRS=40
      LIMTRY=15
      LMCHTO=30
      OMAXD=.5
      TRANHL=2000.
      TRANHU=8000.
```

```
      TRANSF=2300.
*
      RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * *
*INPPRT  INPUT DATA PRINTOUT FOR
*GFP 663  GENERAL FLOW PASSAGE
*    S C SKIRVIN
*
      SUBROUTINE INPPRT
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),PO    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BGO NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1    )),(ACCMNO,BG0(2    )),(ACCPRS,BG0(3    )),
     2(ACCTMP,BG0(4    )),(ALLRUN,BG0(5    )),(AUTOLS,BG0(6    )),
     3(BD    ,BG0(7    )),(BLANKS,BG0(8    )),(BETA1 ,BG0(9    )),
     4(BETA2 ,BG0(10   )),(CIN   ,BG0(11   )),(CEX   ,BG0(12   )),
     5(DEAD  ,BG0(13   )),(DELH  ,BG0(14   )),(DERIV ,BG0(15   )),
     6(ENTRN ,BG0(16   )),(ENTRNC,BG0(17   )),(FD    ,BG0(18   )),
     7(FTIN  ,BG0(19   )),(FTOUT ,BG0(20   )),(FSTPAR,BG0(21   )),
     8(GOAL  ,BG0(22   )),(GAS   ,BG0(23   )),(HIN   ,BG0(24   )),
     9(ITRY  ,BG0(25   )),(KTRCRD,BG0(26   )),(KALCNO,BG0(27   ))
      EQUIVALENCE
     1(KTCHAD,BG0(28   )),(KTWADJ,BG0(29   )),(KTCHTO,BG0(30   )),
     2(KPOW  ,BG0(31   )),(KOPT  ,BG0(32   )),(KOSCIL,BG0(33   )),
     3(KCHOKE,BG0(34   )),(KASE  ,BG0(35   )),(KASTEP,BG0(36   )),
     4(LOC   ,BG0(37   )),(LIMCHK,BG0(38   )),(LMCHTO,BG0(39   )),
     5(LIMTRY,BG0(40   )),(MORCAS,BG0(41   )),(NSKPPR,BG0(42   )),
     6(NSKPHT,BG0(43   )),(NT    ,BG0(44   )),(NHOT  ,BG0(45   )),
     7(NOPRT ,BG0(46   )),(NOSTGE,BG0(47   )),(PARPRT,BG0(48   )),
     8(PRTSUM,BG0(49   )),(RNKIN ,BG0(50   )),(RNKOUT,BG0(51   )),
     9(SVACMN,BG0(52   )),(SVACPR,BG0(53   )),(TOTLND,BG0(54   ))
      EQUIVALENCE
     1(TRY0  ,BG0(55   )),(TRY1  ,BG0(56   )),(TRY2  ,BG0(57   )),
     2(TRY3  ,BG0(58   )),(TEST1 ,BG0(59   )),(TOTLEN,BG0(60   )),
     3(WHI   ,BG0(61   )),(WLO   ,BG0(62   )),(YIELD0,BG0(63   )),
     4(YIELD1,BG0(64   )),(YIELD2,BG0(65   )),(NOINPT,BG0(66   )),
     5(LIMPRS,BG0(67   )),(PRTALL,BG0(68   )),(OMAXD ,BG0(69   )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7          (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
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     1(OMEXIT,BGO(84)),(DPIN,BGO(85)),(DPEX,BGO(86))
     2,(TRANSF,BGO(87)),(TRANHL,BGO(88)),(TRANHU,BGO(89))
     3,UNEWSETTBGOU OD)T(KTPA-,BGOU 1DDT8
     4(QOQBAR,BGO(94)),(NOGEOM,BGO(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2    )),(AFFI  ,BG1(102  )),(BSI   ,BG1(202  )),
     2(BSO   ,BG1(213  )),(BHIGH ,BG1(224  )),(CLOSSI,BG1(237  )),
     3(CLSGEN,BG1(337  )),(CLSMDI,BG1(438  )),(DHD   ,BG1(539  )),
     4(DHI   ,BG1(639  )),(DPARAM,BG1(739  )),(DPARMI,BG1(747  )),
     5(FTABI ,BG1(755  )),(FPARMI,BG1(759  )),(FMULTI,BG1(768  )),
     6(GMASS ,BG1(868  )),(HTABI ,BG1(968  )),(HEDDUM,BG1(974  )),
     7(HMULTI,BG1(987  )),(KPARAM,BG1(1087 )),(KPARMR,BG1(1095 )),
     8(KRSCON,BG1(1103 )),(NDH   ,BG1(1107 )),(NAFL  ,BG1(1207 )),
     9(NLEN  ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(PO    ,BG1(2208 )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
     4(TEXI  ,BG1(2508 )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
     5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
* * * MASTER GROUPING
      DIMENSION BGO(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BGO,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
```

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*
*LIMITED USEAGE
      DIMENSION AFFD(100),DHD(100),OLEND(100),XOL(100)
      EQUIVALENCE(AFFD,AFF(2)),(CLOSSI,CLOSS(2)),(CLSMDI,CLSMOD(2)),
     1(DHD,DH(2)),(DH,DOUTER,ELPMAJ,WIDTH),(AFF,DINNER,ELPMIN,
     2HEIGHT),(FMULTI,FMULT(2)),(HMULTI,HMULT(2)),(ROUND,KRSCON),
     3(RECTNG,KRSCON(2)),(ELLIPS,KRSCON(3)),(RINGS,KRSCON(4)),
     4(OLEND,LENGTH(2)),(NRINGD,NORING(2)),(NAFF,NAFL),(THICKD,
     5THICK(2)),(PTIN,PIN),(TTIN,TIN),(PTEX,PEX),(TEX,TTEX),
     6(CASE,KASE),(CASTEP,KASTEP),(DHD,DHG),(DH,DHGSUB),(AFF,
     7AFFSUB),(OLEND,OL),(LENGTH,OLSUB),(ACCMNO,PER),(NOSTGE,MN),
     8(HTABI(4),A1),(FTABI(3),B1),(FTABI(4),OM),(FMULTI,AKF),(HMULTI,
     9AKH),(CIN,C1),(CEX,C2),(PHISUM,A2),(PHIEX,Q),(NLEN,NOL)
      EQUIVALENCE(NDH,NDHG),(MAXMNO,OMAXD)
*ALL MODIFIED OFF-DESIGN(ANP 443) INPUT VARIABLES
*  ARE IN DIP LIST, FUNCTIONALLY WHEREVER POSSIBLE
      DIMENSION PRTCRS(2,5),CRSHD1(8,4),CRSHD2(8,4)
      TABLE PRTCRS(60HGENERAL     ROUND      RECTANGULAR ELLIPTICAL  C0
     1NC. RINGS ),CRSHD1(192H      HYDR.      FLOW
     2                                                     MAJOR
     3     MINOR                                OUTER      INNER
     4RING     NO        ),CRSHD2(192H      DIAM          AREA
     5                 WIDTH      HEIGHT
     6AXIS        AXIS                                 DIAM        DIAM
     7      THICK     RINGS     )
*END OF STORAGE MAP
*
      KOPT=KOPT
      KGAS=GAS
*CHECK CONTROLS
      IF(KALCNO)100,110,100
  100 IF(MORCAS)105,107,105
*EXIT FROM SR IF PARAMETRIC AND NOT FIRST CASE
  105 IF(FSTPAR)540,540,107
  107 IF(PARPRT)110,110,108
  108 KRT=2
      GO TO 160
*COMPLETE PRINTOUT - SETUP
  110 KRT=1
*CROSS SECTION IDENTIFICATION PRINT
      KD1=1
      DO 130 L=1,4
      IF(KRSCON(L))130,130,120
  120 KD1=L+1
      GO TO 140
  130 CONTINUE
*FORMAT SELECTION CONTROL FOR CROSS SECTION
  140 KD2=0
      IF(KD1-5)160,150,150
  150 KD2=1
*UNIT HEADING PRINTOUT - LENGTH
  160 KD3=1
      IF(FTIN)180,180,170
  170 KD3=2
*TEMP
  180 KD4=1
      IF(RNKIN)220,220,190
```

```
  190 KD4=2
*PRINT UNIT HEADING
  220 CALL PRTUNT(1,KD3,KD4)
      GO TO(230,520,245,320,330,400,410,531),KRT
*UNPROCESSED GEOMETRY
  230 IF(NOGEOM)460,232,460
  232 KD5=1
      IF(KD1-2)240,240,235
  235 KD5=KD1-1
  240 PRINT 32005,KASE,TOTLEN,(PRTCRS(L,KD1),L=1,2)
32005 FORMAT
      SPACE
  CASE    -I       ORIGINAL GEOMETRICAL INPUT DATA
      SPACE
         TOTAL LENGTH =        -1PE4      CROSS SECTION IS-X              -A
      END OF FORMAT
*
  245 PRINT 32006,(CRSHD1(L,KD5),L=1,8),(CRSHD2(L,KD5),L=1,8)
32006 FORMAT
      SPACE
                         -X                                                -A
 STGE   X/L       LENGTH                                                   -A
      SPACE
      END OF FORMAT
*
      IF(KRT-2)250,520,260
  250 NL=1
      NU=NOSTGE
      EXIT=1.
      IF(40-NOSTGE)255,260,260
  255 NU=40
      EXIT=0.
  260 IF(KD2)270,265,270
*NOT CONCENTRIC RING
  265 PRINT 32007,(N,XOL(N),OLEND(N),DHD(N),AFFD(N),
     1N=NL,NU)
32007 FORMAT((I4,0PF8.4,1P3E12.4))
      GO TO 280
*CONCENTRIC RINGS
  270 PRINT 32008,(N,XOL(N),OLEND(N),DHD(N),AFFD(N),THICKD(N),
     1NRINGD(N),N=NL,NU)
32008 FORMAT((I4,0PF8.4,1P4E12.4,I6))
  280 IF(EXIT)285,285,300
  285 NL=NU+1
      KRT=3
      IF(84-NOSTGE)290,295,295
  290 IF(84-NU)295,295,297
  295 NU=NOSTGE
      EXIT=1.
      GO TO 220
  297 NU=84
      GO TO 220
*
*PROCESSED GEOMETRY
  300 KRT=4
      NL=1
      NU=NOSTGE
```

```
      IF(40-NOSTGE)310,220,220
  310 NU=40
      EXIT=0.
      GO TO 220
  320 PRINT 32010,KASE,TOTLND,(PRTCRS(L,KD1),L=1,2)
32010 FORMAT
      SPACE
  CASE      -I   PROCESSED GEOMETRICAL INPUT AND F- AND H-MULTIPLIERS
      SPACE
         TOTAL LENGTH =         -1PE4     CROSS SECTION IS-X             -A
      END OF FORMAT
*
  330 PRINT 32012,(N,XOLD(N),OLENI(N),DHI(N),AFFI(N),HMULTI(N),
     1FMULTI(N),N=NL,NU)
32012 FORMAT
      SPACE
                                        HYDR.            FLOW      H-        F-
 STGE    X/L        LENGTH              DIAM             AREA      MULT      MULT
      SPACE
  -I     -0PF4        -1PE5                -E5              -E5    -0PF4       -F4
      REPEAT 1
      END OF FORMAT
*
      IF(EXIT)340,340,380
  340 NL=NU+1
      KRT=5
      IF(84-NOSTGE)350,350,360
  350 IF(84-NU)360,360,370
  360 NU=NOSTGE
      EXIT=1.
      GO TO 220
  370 NU=84
      GO TO 220
*
*REMAINING STAGEWISE INPUT
  380 KRT=6
      NL=1
      NU=NOSTGE
      IF(38-NOSTGE)390,220,220
  390 NU=38
      EXIT=0.
      GO TO 220
  400 PRINT 32015,KASE,AUTOLS,ENTRNC,BETA1,BETA2
32015 FORMAT
      SPACE
  CASE      -I   POWER PROFILE AND INTERSTAGE LOSS INPUT
      SPACE
       AUTOLOSS CALC =-F0
       INTENDED ENTRANCE LENGTH EFFECT =-F0
         BETA1 =         -1PE4    BETA2 =           -E4
      END OF FORMAT
*
  410 PRINT 32017,(N,CLOSSI(N),CLSMDI(N),PHISUM(N),PHIEX(N),
     1P0(N),P1(N),P2(N),N=NL,NU)
32017 FORMAT
      SPACE
      INTRSTGE  AUTO LOSS
```

```
 STGE  LOSS COF     MULT        PHISUM     PHIEX        PO          P1             P2
        SPACE
  -I      -0PF4          -F4         -F4        -F4        -F4         -F4          -F4
        REPEAT 1
        END OF FORMAT
*
        IF(EXIT)420,420,460
  420  NL=NU+1
       KRT=7
        IF(80-NOSTGE)430,430,440
  430  IF(80-NU)440,440,450
  440  NU=NOSTGE
       EXIT=1.
       GO TO 220
  450  NU=80
       GO TO 220
*CHECK NEED FOR LENGTH UNIT CHANGES
  460  IF(FTIN)470,510,470
  470  DO 480 N=1,NOSTGE
       DHI(N)=DHI(N)*12.
       OLENI(N)=OLENI(N)*12.
       AFFI(N)=AFFI(N)*144.
  480  CONTINUE
       TOTLND=TOTLND*12.
*
*FLOW INPUT DATA
  510  KRT=2
       GO TO 220
  520  PRINT 32020,KASE,PRTGAS(KGAS),GAS,KOPT,(HTABI(L),
     1L31,6),(FTAB+(LDTL31T-D,$MBULKT,BBULKT3                                2
     2T*E0TQSE0T,E0TQX0P-G,,E0PT+9                              KKNC0-KG0-OC+W33 Q 52
     3,ACCPRS,ACCMNO,ACCTMP,LIMTRY,LIMCHK,LMCHTO,LIMPRS
32020  FORMAT
       SPACE
  CASE      -I     FLOW INPUT DATA (GAS IS-X     -A,NO -F0)
           * * * WILL EXECUTE OPTION NO -I * * *
       SPACE
    FRICTION FACT AND HEAT TRANSFER CORRELATION FORMS
      N(NUS)=A*(N(PR)**B)*(N(RE)**C)
      F=D*(N(RE)**E)
     NUMERICAL VALUES (L FOR LAMINAR, T FOR TURBULENT)
      AL=      -1PE3, BL=         -E3, CL=         -E3
      AT=          -E3, BT=         -E3, CT=         -E3
      DL=          -E3, EL=         -E3, DT=         -E3, ET=          -E3
       SPACE
    BULK TEMP FOR HEAT TRANSFER CORRELATION(0=NO, 1=YES)
       LAMINAR =-I   TURBULENT =-I
       SPACE
      TRANSITION RANGE FOR N(NU)         -1PE4 TO          -E4
      TRANSITION FOR FRICTION AT          -E4
       SPACE
                  TOTAL           STATIC         TOTAL
                  PRESS           PRESS          TEMP
    INLET           -1PE5                          -0PF2
    EXIT            -1PE5            -E5           -0PF2
    EX/IN              -F5                            -F5
       PSEX/PTIN =          -F5
```

```
      WEIGHT FLOW =          -1PE5    HEAT RELEASE =              -E5
      QBAR =           -E5    Q/QBAR =           -E5
        MAX WALL TEMP =      -0PF2 AT STAGE NO  -I
      SPACE 2
   ACCURACIES (FRACTIONAL UNLESS NOTED)
        PRESS       MACH NO    WALL TEMP(DEG)
         -1PE3          -E3         -0PF2
      SPACE
   COUNTER LIMITS ON ITERATIONS
       OPTION ITERATION = -I
       CHOKES/WT FLOW = -I    CHOKES/CASE = -I
       STAGE PRESS AND WALL TEMP = -I
      END OF FORMAT
*
      IF(FSTPAR)540,540,530
  530 KTOTPR=1
      KRT=8
      GO TO 220
  531 DO 534 K=1,4
      KD=KONPAR(K,KOPT)
      IF(KPARMR(KD))532,534,534
  532 KPARMR(KD)=0
  534 KTOTPR=KTOTPR*(KPARMR(KD)+1)
      PRINT 32025,KASE,KTOTPR,DPARAM(3),DPARAM(7),DPARAM(6),
     1DPARAM(5),KPARAM(3),KPARAM(7),KPARAM(6),KPARAM(5),
     2DPARAM(8),DPARAM(4),DPARAM(2),DPARAM(1),
     3KPARAM(8),KPARAM(4),KPARAM(2),KPARAM(1)
32025 FORMAT
      SPACE 2
  CASE      -I        PARAMETRIC SETUP  (      -I CASES)
      SPACE
                        EXIT         WEIGHT      EXIT TOT    EXIT STAT
                        TEMP          FLOW        PRESS        PRESS
      SPACE
  INCREMENT            -1PE4          -E4          -E4          -E4
  NO OF TIMES           -I           -I           -I           -I
      SPACE 2
                       HEAT        MAX AVE       INLET      INLET TOT
                      RELEASE     SURF TEMP      TEMP         PRESS
      SPACE
  INCREMENT              -E4          -E4          -E4          -E4
  NO OF TIMES           -I           -I           -I           -I
      END OF FORMAT
*
*SR FINISHED
  540 CONTINUE
      RETURN
      END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*ITRCON   SR WHICH CONTROLS EXECUTION OF CALCULATION
*  OPTION FOR
*GFP 663  GENERAL FLOW PASSAGE
*     S C SKIRVIN
*
      SUBROUTINE ITRCON
*
*BEGIN STORAGE MAP
```

```
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7          (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102   )),(BSI   ,BG1(202   )),
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224   )),(CLOSSI,BG1(237   )),
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438   )),(DHD   ,BG1(539   )),
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739   )),(DPARMI,BG1(747   )),
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759   )),(FMULTI,BG1(768   )),
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968   )),(HEDDUM,BG1(974   )),
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087  )),(KPARMR,BG1(1095  )),
     8(KRSCON,BG1(1103  )),(NDH   ,BG1(1107  )),(NAFL  ,BG1(1207  )),
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     9(NLEN   ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(P0    ,BG1(2208 )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
     4(TEXI  ,BG1(2508 )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
     5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
      DIMENSION TSTGRP(4)
      EQUIVALENCE(TRYP,TSTGRP),(TESTP,TSTGRP(2)),(TRYM,TSTGRP(3)),
     1(TESTM,TSTGRP(4))
*END OF STORAGE MAP
*
      KOPT=KOPT
      SVACMN=ACCMNO
      SVACPR=ACCPRS
*INITIALIZATION
      KCHOKE=0
      HIN=TMPENT(TIND,GAS,1)
*ARE ANY OPTIONS BEING EXERCISED
```

```
 1090 IF(NSKPHT)1250,1095,1250
 1095 IF(NSKPPR)1250,1100,1250
*MAKE PRE-CALCULATION SETUP
 1100 IF(KOPTH)1145,1105,1105
*PRE-ITERATION INITIALIZATION
*GOAL IS DESIRED VALUE OF DEPENDENT VARIABLE
*TRY0,1,2,3 ARE RUNNING VALUES OF INDEPENDENT VARIABLE
 1105 KOSCIL=0
      ITRY=1
      KTCHTO=0
      KTWADJ=0
      OMAX1=OMAXD
      TRYMAX=0.
      TRYMIN=1.E+20
      WHI=1.E+20
      WLO=0.
      DO 1106 L=1,4
      BGO(L+54)=0.
 1106 TSTGRP(L)=0.
*KONOPT(2,KOPT) RETRIEVES INDEPENDENT VARIABLE FROM BSO
      KDI=KONOPT(2,KOPT)
*KONOPT(1,KOPT) RETRIEVES DEPENDENT VARIABLE FROM BSO
      KDD=KONOPT(1,KOPT)
      CALL XPRNT(6HKDI,DD,KDI,KALCNO,2,KCHK1)
      IF(KDI-1)1111,1108,1107
 1107 WHI=FLWFUN(AFFI(1),PIND,TIND,.9,GAS)
      GO TO 1111
 1108 WLO=PRSFUN(AFFI(1),WD,TIND,.9,GAS)
*SET CONVERGENCE CRITERIA
 1111 IF(KOPT-2)1112,1112,1113
 1112 DMCONV=ACCTMP
      GO TO 1114
 1113 DMCONV=ACCPRS
 1114 CONTINUE
      CALL FPRNT(6HDMCONV,DMCONV,ITRY,1,KCHK1)
      IF(BSO(KDI))1115,1115,1140
 1115 IF(6 KOPT)1130,1120,1120
*CHECK IF STARTING VALUE NEEDED
 1120 IF(WD)1125,1125,1140
 1125 WD=FLWFUN(AFFI(1),PIND,TIND,.1,GAS)
      GO TO 1140
 1130 PIND=PRSFUN(AFFI(1),WD,TIND,.1,GAS)
 1140 TRY0=BSO(KDI)
      GOAL=BSO(KDD)
      CALL FPRNT(4HGOAL,GOAL,ITRY,1,KCHK1)
 1145 CONTINUE
      IF(13-KOPT)1147,1147,1148
*FLOW NOT USER-SUPPLIED
 1147 WD=QTOTD/(TMPENT(TEXD,GAS,1)-HIN)
      GO TO 1170
*CHECK IF TEXD USER-SUPPLIED
 1148 KRT=1
 1149 DO 1150 M=1,7
      IF(KOPT-2*M+1)1150,1160,1150
 1150 CONTINUE
      GO TO 1165
 1160 TEXD=TMPENT(QTOTD/WD+HIN,GAS,-1)
```

```
 1165 GO TO(1170,1476),KRT
 1170 CONTINUE
      T2=BSO(KDI)
      CALL FPRNT(3HBSO,BSO,ITRY,11,KCHK1)
*
*ITERATION SECTION
 1250 CONTINUE
*CALC BULK TEMPS TO PERMIT INDEPENDENT USE OF
*  PRES DROP OR WALL TEMP ROUTINES
*  ALSO CALC MASS VELOCITIES
 1251 DELH=TMPENT(TEXD,GAS,1)-HIN
      DO 1252 N=1,NOSTGE
      GMASS(N)=WD/AFFI(N)
 1252 TEXI(N)=TMPENT(PHISUM(N)*DELH+HIN,GAS,-1)
      IF(NSKPPR)13502,1254,13502
*MAKE PRESSURE DROP CALC
 1254 CALL DPFRLT(0)
      IF(NSKPHT)1600,1255,1600
*DID STAGE EXIT PRESS FAIL TO CONVERGE
 1255 IF(SENSE LIGHT 2)1505,1256
 1256 CONTINUE
*
 1259 KTCHAD=0
*DID CHOKE OCCUR
      IF(KCHOKE)1260,13500,1260
 1260 NT=160
      CALL FPRNT(5HWHILO,WHI,KTCHTO,2,KCHK1)
      IF(KOPTH)1262,1270,1270
*OPTIONS 11-13 HAVE NO CHOKE REMEDIAL
 1262 LOC=1
      GO TO 1500
*HAS TOTAL ADJ COUNTER BEEN EXCEEDED
 1270 IF(LMCHTO-KTCHTO)1272,1272,1280
 1272 LOC=3
      GO TO 1500
 1280 CALL UNCHKE
*HAS CHOKE ADJ COUNTER LIMIT BEEN EXCEEDED FOR SINGLE
*  WT FLOW
      IF(SENSE LIGHT 2)1505,1290
 1290 CONTINUE
      CALL SETYLD(ITRY,YIELD2)
*TEST IF GOAL REACHABLE WITH TRY2 FROM UNCHKE
      IF(KOPT-2)1300,1300,1320
*WALL TEMP
 1300 TEST1=YIELD2-GOAL
      IF(ABSF(TEST1) ACCTMP)1600,1600,1310
 1310 IF(TEST1)1344,1600,1340
*PRES
 1320 TEST1=GOAL-YIELD2
      IF(ABSF(TEST1/GOAL)-SVACPR)1600,1600,1330
 1330 IF(TEST1)1340,1600,1344
*SEE IF UNCHKE CAN MAKE FURTHER ADJUSTMENT
 1340 IF(KDI-1)1339,1344,1339
 1339 IF((WHI-WLO)/WHI-1.E-6)1342,1342,1341
 1341 OMAX1=(.9+OMAX1)/2.
      GO TO 1280
*NEG OR ZERO IS FAILURE
```

```
 1342 LOC=2
      GO TO 1500
*UPDATE TOTAL CHOKES COUNTER
 1344 KTCHTO=KTCHTO+KTCHAD
      T2=BSO(KDI)
      IF(ITRY-2)1346,1347,1348
 1346 TRY0=BSO(KDI)
      GO TO 1353
 1347 TRY1=BSO(KDI)
      GO TO 1353
 1348 TRY2=BSO(KDI)
      GO TO 1353
* CHECK NEED FOR WALL TEMP CALC
13500 IF(KOPT-2)13502,13502,13501
13501 IF(KOPTH)13502,1350,1350
13502 CALL TWLT(0)
*DID STAGE EXIT WALL TEMP FAIL TO CONVERGE
      IF(SENSE LIGHT2) 1505,13504
13504 IF(NSKPPR)1600,1350,1600
*
*NORMAL SEQUENCE AFTER NO CHOKE
*TEST IF ITERATING
 1350 IF(KOPTH)1600,1352,1352
 1352 CALL SETYLD(ITRY,YIELD2)
 1353 TEST2=GOAL-YIELD2
*TEST CONVERGENCE
      CALL FPRNT(6HYLD0-2,YIELD0,ITRY,3,KCHK1)
      IF(KOPT-2)1356,1356,1354
*PRES
 1354 TEST2=TEST2/GOAL
 1356 TEST1=ABSF(TEST2)
*START BOUND TEST SEQUENCE
      IF(TEST2)1363,1600,1358
*HAS PLUS BOUND BEEN SET
 1358 IF(TESTP)1361,1359,1361
*SET PLUS BOUND
 1359 TESTP=TEST2
      TRYP=T2
      GO TO 1368
*TEST PLUS BOUND
 1361 IF(TESTP-TEST2)1368,1368,1359
*HAS NEGATIVE BOUND BEEN SET
 1363 IF(TESTM)1366,1364,1366
*SET NEGATIVE BOUND
 1364 TESTM=TEST2
      TRYM=T2
      GO TO 1368
*TEST NEGATIVE BOUND
 1366 IF(TEST2-TESTM)1368,1368,1364
*TEST IF MAX-MIN CAN BE SET
 1368 IF(TESTM*TESTP)1370,1380,1370
*SET MAX-MIN
 1370 TRYMAX=MAX1F(TRYM,TRYP)
      TRYMIN=MIN1F(TRYM,TRYP)
      CALL FPRNT(6HTRYMAX,TRYMAX,ITRY,1,KCHK1)
      CALL FPRNT(6HTRYMIN,TRYMIN,ITRY,1,KCHK1)
```

```
 1380 CONTINUE
      CALL FPRNT(5HTEST2,TEST2,ITRY,1,KCHK1)
      CALL FPRNT(6HTSTGRP,TSTGRP,ITRY,4,KCHK1)
      IF(TEST1-DMCONV)1510,1510,1390
*NOT CONVERGED - TEST COUNTER LIMIT
 1390 IF(LIMTRY-ITRY)1392,1395,1395
*NEG FAILED
 1392 NT=170
      LOC=1
      GO TO 1500
*CHECK FOR OSCILLATION
 1395 IF(TEST1-3.*DMCONV)1400,1400,1415
*STEP OSCILLATION COUNTER
 1400 KOSCIL=KOSCIL+1
      IF(4 KOSCIL)1405,1405,1420
*TIGHTEN CALC TOLERANCES
 1405 IF(4.*ACCPRS-SVACPR)1406,1406,1410
*NEG OR ZERO IS FAILURE
 1406 NT=170
      LOC=2
      GO TO 1500
 1410 ACCPRS=.5*ACCPRS
      ACCMNO=.5*ACCMNO
*NORMAL CONTINUATION
 1415 KOSCIL=0
*STEP ITERATION COUNTER
 1420 ITRY=ITRY+1
*IS THIS FIRST ITERATION
      IF(ITRY-3)1430,1480,1490
*
*FIRST ITERATION
 1430 YIELD0=YIELD2
      IF(KOPT-2)1432,1432,1434
*TWMAX
 1432 TRY3=TRY0*(YIELD0/GOAL)**1.25
      GO TO 1445
*PRES
 1434 IF(6 KOPT)1438,1436,1436
*INLET PRESS IS FIXED
 1436 TRY3=TRY0*((PIND-GOAL)/(PIND-BSO(KDD)))**1.25
      GO TO 1445
 1438 TRY3=TRY0*GOAL/BSO(KDD)
*AN EXIT PRESS IS FIXED
*SET FOR NEXT CALL DPFRLT
 1445 T1=TRY0
 1448 T2=TRY3
*HAVE MAX-MIN BEEN ESTABLISHED
      IF(TRYMAX*TRYMIN)1456,1449,1456
*TEST TO INSURE NO NEGATIVE ITRY AND NOT EXCEED CHOKE LIMIT
 1449 IF(T2)1450,1450,1451
 1450 T2=.1*T1
      GO TO 1466
 1451 IF(WHI-T2)1452,1452,1466
 1452 TI=T1+.9*(WHI-T1)
      GO TO 1466
*DELETE 1873-1874
*TEST FOR T2 BETWEEN MAX AND MIN
```

```
 1456 IF(T2-TRYMIN)1460,1460,1458
 1458 IF(TRYMAX-T2)1460,1460,1466
 1460 T2=(TRYMAX+TRYMIN)/2.
*FINISH PROCESSING
 1466 BSO(KDI)=T2
      IF(ITRY-3)1467,1468,1468
 1467 TRY1=T2
      GO TO 1469
 1468 TRY2=T2
 1469 KRT=2
      GO TO 1149
 1476 CONTINUE
      CALL FPRNT(6HTRY0-3,TRY0,ITRY,4,KCHK1)
      CALL FPRNT(3HBSO,BSO,ITRY,8,KCHK1)
*TEST FOR PULL ON TIME
      IF(SENSE SWITCH 4)1478,1251
 1478 NT=999
      LOC=1
      GO TO 1500
*
*
*SECOND ITERATION
 1480 YIELD1=YIELD2
      CALL EXTRAP(0,0,TRY0,YIELD0,TRY1,YIELD1,TRY3,
     1GOAL,2)
 1485 T1=TRY1
      GO TO 1448
*
*THIRD ITERATION
 1490 CALL EXTRAP(TRY0,YIELD0,TRY1,YIELD1,TRY2,YIELD2,
     1TRY3,GOAL,3)
      TRY0=TRY1
      TRY1=TRY2
      TRY2=TRY3
      YIELD0=YIELD1
      YIELD1=YIELD2
      GO TO 1485
*END OF ITERATION SECTION
*
*ERROR COMMENT FOR ITERATION FAILURE
 1500 CALL NETERR(NT,LOC)
 1505 SENSE LIGHT 2
 1510 IF(KOPT-2)1600,1600,1520
 1520 CALL TWLT(0)
*
*SET UP MAJOR OUTPUT
 1600 CALL SETYLD(0,YIELD2)
 1604 IF(SENSE LIGHT 2)1601,1605
 1601 SENSE LIGHT 2
      GO TO 1700
*SUCCESSFUL COMPLETION
 1605 KALCNO=KALCNO+1
*MAKE ENTRIES IN SUMMARY TABLES
      KSVTAB(1,KALCNO)=KASE
      KSVTAB(13,KALCNO)=NHOT
      DO 1610 L=1,11
 1610 SAVTAB(L+1,KALCNO)=BSO(L)
```

```
*
*FINISHED
 1700 CONTINUE
      KTCHAD=0
      ACCMNO=SVACMN
      ACCPRS=SVACPR
      RETURN
      END(0,0,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
*OUTPUT  SR FOR SINGLE-CASE OUTPUT FOR
*GFP 663  GENERAL FLOW PASSAGE
*    S C SKIRVIN
*
      SUBROUTINE OUTPUT
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7          (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
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     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFO  ,BG1(2    )),(AFFI  ,BG1(102  )),(BSI   ,BG1(202  )),
     2(BSO   ,BG1(213  )),(BHIGH ,BG1(224  )),(CLOSSI,BG1(237  )),
     3(CLSGEN,BG1(337  )),(CLSMDI,BG1(438  )),(DHD   ,BG1(539  )),
     4(DHI   ,BG1(639  )),(DPARAM,BG1(739  )),(DPARMI,BG1(747  )),
     5(FTABI ,BG1(755  )),(FPARMI,BG1(759  )),(FMULTI,BG1(768  )),
     6(GMASS ,BG1(868  )),(HTABI ,BG1(968  )),(HEDDUM,BG1(974  )),
     7(HMULTI,BG1(987  )),(KPARAM,BG1(1087 )),(KPARMR,BG1(1095 )),
     8(KRSCON,BG1(1103 )),(NDH   ,BG1(1107 )),(NAFL  ,BG1(1207 )),
     9(NLEN  ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(P0    ,BG1(2208 )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
     4(TEXI  ,BG1(2508 )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
     5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1373),BG3(302),
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     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
*END OF STORAGE MAP
*
      NOSTGE=NOSTGE
      KGAS=GAS
      REYNIN=GMASS(1)*DHI(1)*12./VISC(TIND,GAS)
      REYNEX=GMASS(NOSTGE)*DHI(NOSTGE)*12./VISC(TEXD,GAS)
*IS THIS A PARAMETRIC STUDY
      IF(MORCAS)104,104,95
*IS THIS FIRST CASE FOR PARAM STUDY
   95 IF(FSTPAR)100,100,104
*IS PARTIAL PRINT BEING USED
  100 IF(PARPRT)104,104,105
  104 KTLINE=0
*SET UNITS   LENGTH
  105 KD1=1
*SET UP STATIC PRESSURES IF NEEDED
      IF(PRTALL)106,109,106
  106 DO 107 N=1,NOSTGE
  107 PSEXI(N)=PSTAT(PEXI(N),TEXI(N),OMEXI(N),GAS)
      IF(DPINT(NOSTGE))108,109,108
  108 PSEXI(NOSTGE)=PSTAT(PEXI(NOSTGE)-DPINT(NOSTGE),
     1TEXI(NOSTGE),OMEXIT,GAS)
  109 CONTINUE
      IF(FTOUT)120,120,110
  110 KD1=2
*TEMP
  120 KD2=1
      IF(RNKOUT)140,140,130
  130 KD2=2
  140 KRT=1
      IF(MORCAS)150,150,142
  142 IF(FSTPAR)144,144,150
  144 IF(PARPRT)150,150,160
*UNIT HEADING
  150 CALL PRTUNT(2,KD1,KD2)
      GO TO(160,222,243,275,280,245),KRT
*CHECK NEED FOR UNIT CHANGING
  160 IF(FTOUT)200,200,170
*FEET FOR OUTPUT, ALSO USED FOR RESET IN PARAMETRIC
  170 TRAN2=.00694444
      KRT1=0
  180 IF(PARPRT)185,185,195
  185 DO 190 N=1,NOSTGE
      GMASS(N)=GMASS(N)/TRAN2
      PDYEXI(N)=PDYEXI(N)/TRAN2
      DPINT(N)=DPINT(N)/TRAN2
      PEXI(N)=PEXI(N)/TRAN2
      PSEXI(N)=PSEXI(N)/TRAN2
      CONVEC(N)=CONVEC(N)/TRAN2
  190 CONTINUE
      PDYIN=PDYIN/TRAN2
      PDYEX=PDYEX/TRAN2
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      DPIN=DPIN/TRAN2
      DPEX=DPEX/TRAN2
  195 PEXD=PEXD/TRAN2
      PIND=PIND/TRAN2
      PSEXD=PSEXD/TRAN2
      IF(KRT1)200,200,350
*TEMP
  200 CONTINUE
      IF(RNKOUT)210,210,211
*DEG F IN OUTPUT
  210 CALL CONTMP(GRTMPO,3,GRTMPO,-1)
      CALL CONTMP(TEXI,NOSTGE,TEXI,-1)
      CALL CONTMP(TW,NOSTGE,TW,-1)
*BASIC OUTPUT
  211 PIMPX=PIND-PEXD
      TIMTX=TIND-TEXD
*IS CHOKE COMMENT NEEDED
      IF(KCHOKE)212,213,212
  212 KTLINE=KTLINE+5
      PRINT 32005,KCHOKE
32005 FORMAT
      SPACE
 * * * * * * * * * * * * * * * * * * * *
 * CHOKE OCURRED IN STAGE  -I. IGNORE   *
 * ALL RESULTS THERE AND DOWNSTREAM.    *
 * * * * * * * * * * * * * * * * * * * *
      END OF FORMAT
*
  213 KTLINE=KTLINE+19
      IF(50-KTLINE)221,222,222
  221 KRT=2
      KTLINE=21
      GO TO 150
  222 CONTINUE
      PRINT 32010,KASE,PRTGAS(KGAS),KGAS,WD,TWMAXD,NHOT,
     1QTOTD,PIND,TIND,PDYIN,OMINLT,REYNIN,PEXD,PSEXD,
     2TEXD,PDYEX,OMEXIT,REYNEX,PIMPX,TIMTX,PTPID,
     3TXTID,PSPID
32010 FORMAT
      SPACE
  CASE     -I      FLOW AND TEMPERATURE RESULTS (GAS IS-X     -A, NO -I)
      SPACE
   WEIGHT FLOW =          -1PE5   MAX AVE WALL TEMP =   -0PF2 AT STAGE  -I
               HEAT ADDITION =          -1PE4
      SPACE
             TOTAL          STATIC     TOTAL       DYNAMIC     MACH        REYNOLDS
             PRESS          PRESS      TEMP         PRESS       NO             NO
      SPACE
 INLET       -0PF3                      -F1        -1PE4     -0PF4         -1PE5
  EXIT       -0PF3           -F3        -F1        -1PE4     -0PF4         -1PE5
 IN-EX         -E4                    -0PF2
 RATIO         -F5                      -F4     PSEX/PTIN =       -F5
      END OF FORMAT
*
*IS ENTRANCE OR EXIT LOSS PRINTOUT REQUIRED
      IF(CIN)230,225,230
  225 IF(CEX)230,235,230
```

```
  230 PIMDP=PIND-DPIN
      PRINT 32015,CIN,DPIN,PIMDP,CEX,DPEX,PEXI(NOSTGE)
 32015 FORMAT
      SPACE 2
    ENTRANCE AND EXIT LOSSES
         LOSS COEFF   P-TOT LOSS   TOT PRESS
  INLET       -1PE4         -E4        -0PF3(AFTER)
   EXIT       -1PE4         -E4        -0PF3(BEFORE)
      END OF FORMAT
*
      GO TO 240
  235 KTLINE=KTLINE-7
*IS NORMAL STAGE-BY-STAGE PRINTOUT WANTED
  240 IF(PARPRT)239,239,310
  239 IF(17-NOSTGE)242,241,241
  241 NL=1
      NU=NOSTGE
      EXIT=1.
      GO TO 245
  242 KRT=3
      NL=1
      NU=NOSTGE
      EXIT=1.
      GO TO 150
  243 IF(41-NOSTGE)244,245,245
  244 NU=41
      EXIT=0.
*NORMAL STAGEWISE OUTPUT
  245 PRINT 32020,KASE,(N,PEXI(N),DPINT(N),TEXI(N),TW(N),
     1OMEXI(N),REYNO(N),N=NL,NU)
32020 FORMAT
      SPACE 2
  CASE      -I   STAGE BY-STAGE OUTPUT RESULTS
      SPACE
          EXIT       INTRSTGE     EXIT    EXIT      EXIT         AVE
 STGE     P-TOT     P TO LOSS     T-TOT   T-WALL    MACH NO      REYN NO
      SPACE
  -I       -0PF3          -F5       -F1       -F1       -F4          -1PE5
      REPEAT 1
      END OF FORMAT
*
      IF(EXIT)250,246,250
  246 NL=NU+1
      KRT=6
      IF(82-NOSTGE)247,248,248
  247 IF(82-NU)248,248,249
  248 NU=NOSTGE
      EXIT=1.
      GO TO 150
  249 NU=82
      GO TO 150
*IS REMAINING STAGEWISE OUTPUT WANTED
  250 IF(PRTALL)310,310,260
*REMAINING STAGEWISE OUTPUT
  260 KRT=4
      GO TO 150
  275 NL=1
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      NU=NOSTGE
      IF(41-NOSTGE)276,280,280
  276 NU=41
      EXIT=0.
  280 PRINT 32025,KASE,(N,PDYEXI(N),PSEXI(N),CLSGEN(N),
     1CONVEC(N),FRIC(N),GMASS(N),N=NL,NU)
32025 FORMAT
      SPACE 2
 CASE    -I  MISCELLANEOUS STAGE-BY-STAGE OUTPUT
      SPACE
          EXIT       EXIT   AUTO INTR-     H-          F-         MASS
 STGE     P-DYN     P STAT   STG COEFF    COEFF       FACTOR     VELOCITY
      SPACE
 -I        -1PE4     -0PF3       -F5      -1PE4          -E4           -E4
      REPEAT 1
      END OF FORMAT
*
      IF(EXIT)310,285,310
  285 NL=NU+1
      KRT=5
      IF(82-NOSTGE)290,300,300
  290 IF(82-NU)300,300,295
  295 NU=82
      GO TO 150
  300 NU=NOSTGE
      EXIT=1.
      GO TO 150
*CHECK IF PARAMETRIC REQUIRING UNIT RESET
  310 IF(MORCAS)350,350,315
  315 IF(RNKOUT)330,320,330
  320 CALL CONTMP(GRTMPO,3,GRTMPO,1)
  330 IF(FTOUT)350,350,340
  340 TRAN2=144.
      KRT2=1
      GO TO 195
*SR FINISHED
  350 CONTINUE
      RETURN
      END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*PRTUNT63  SR TO PRINT UNIT HEADING FOR
      SUBROUTINE PRTUNT(KD1,KD2,KD3)
      DIMENSION BHIGH(12),BWHEN(2),BUNLEN(4,2),BUNTMP(2)
      EQUIVALENCE(BHIGH,BG1(224)),(BWHEN,BHIGH),(BUNLEN,
     1BHIGH(3)),(BUNTMP,BHIGH(11))
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801))
      COMMON BG
* * * END OF MASTER GROUPING
      K1=KD1
      K2=KD2
      K3=KD3
      WRITE OUTPUT TAPE 3,32750,BWHEN(K1),(BUNLEN(L,K2),
     1L=1,4),BUNTMP(K3)
32750 FORMAT
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      RESTORE
      SPACE
             * * * GENERAL FLOW PASSAGE (ANP 663) * * *
 -X    -A UNITS ARE-X                          -A    -A BTU/SEC, LBM/SEC.
      END OF FORMAT
*
      RETURN
      END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*READIN    DATA LOADING AND PARAMETRIC STUDY CONTROL FOR
*  GENERAL FLOW PASSAGE (ANP 663)
*
      SUBROUTINE READIN
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0    (100 ),P1    (100 ),
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE
      EQUIVALENCE
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7          (DMCONV,BG0(75))T(KD+,BG0(76))TUKDD,BG0(77)-3-
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      878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
      9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS;BG0(82))
       EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
      1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
      2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
      3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
      4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
       EQUIVALENCE
      1(AFFD  ,BG1(2    )),(AFFI  ,BG1(102  )),(BSI   ,BG1(202  )),
      2(BSO   ,BG1(213  )),(BHIGH ,BG1(224  )),(CLOSSI,BG1(237  )),
      3(CLSGEN,BG1(337  )),(CLSMDI,BG1(438  )),(DHD   ,BG1(539  )),
      4(DHI   ,BG1(639  )),(DPARAM,BG1(739  )),(DPARMI,BG1(747  )),
      5(FTABI ,BG1(755  )),(FPARMI,BG1(759  )),(FMULTI,BG1(768  )),
      6(GMASS ,BG1(868  )),(HTABI ,BG1(968  )),(HEDDUM,BG1(974  )),
      7(HMULTI,BG1(987  )),(KPARAM,BG1(1087 )),(KPARMR,BG1(1095 )),
      8(KRSCON,BG1(1103 )),(NDH   ,BG1(1107 )),(NAFL  ,BG1(1207 )),
      9(NLEN  ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
       EQUIVALENCE
      1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
      2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
      3(P0    ,BG1(2208 )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
      4(TEXI  ,BG1(2508 )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
      5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
      6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
      7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
       DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
       EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
      1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
       EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
       EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
      1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
       DIMENSION GRTMPI(3),GRTMPO(3)
       EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
      1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
      2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
      3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
      4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
      5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
      6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
       EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
      1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
      2HTABI(6))
       EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
      1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
      27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
      3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
      4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
      5(NOQTOT,KPARAM(8))
*LIMITED USEAGE
       DIMENSION AFFD(100),DHD(100),OLEND(100),XOL(100)
       EQUIVALENCE(AFFD,AFF(2)),(CLOSSI,CLOSS(2)),(CLSMDI,CLSMOD(2)),
```

```
     1(DHD,DH(2)),(DH,DOUTER,ELPMAJ,WIDTH),(AFF,DINNER,ELPMIN,
     2HEIGHT),(FMULTI,FMULT(2)),(HMULTI,HMULT(2)),(ROUND,KRSCON),
     3(RECTNG,KRSCON(2)),(ELLIPS,KRSCON(3)),(RINGS,KRSCON(4)),
     4(OLEND,LENGTH(2)),(NRINGD,NORING(2)),(NAFF,NAFL),(THICKD,
     5THICK(2)),(PTIN,PIN),(TTIN,TIN),(PTEX,PEX),(TEX,TTEX),
     6(CASE,KASE),(CASTEP,KASTEP),(DHD,DHG),(DH,DHGSUB),(AFF,
     7AFFSUB),(OLEND,OL),(LENGTH,OLSUB),(ACCMNO,PER),(NOSTGE,MN),
     8(HTABI(4),A1),(FTABI(3),B1),(FTABI(4),OM),(FMULTI,AKF),(HMULTI,
     9AKH),(CIN,C1),(CEX,C2),(PHISUM,A2),(PHIEX,Q),(NLEN,NOL)
      EQUIVALENCE(NDH,NDHG),(MAXMNO,OMAXD)
*ALL MODIFIED OFF-DESIGN(ANP 443) INPUT VARIABLES
*  ARE IN DIP LIST, FUNCTIONALLY WHEREVER POSSIBLE
      EQUIVALENCE(HEADER,HEDDUM(12))
*FOR READIN ONLY
*SPELLINGS, OFFSETS, ETC.
      DIMENSION
     1AFF    (101 ),CLSMOD(101 ),CLOSS (101 ),DH     (101 ),LENGTH(101 ),
     2NORING(101),THICK(101),FMULT(101),HMULT(101)
      EQUIVALENCE(NOSTGE,STAGES)
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
*END OF STORAGE MAP
*
      KOPT=KOPT
      DUMDIP=0.
*IS PROGRAM IN PARAMETRIC LOOP
      IF(MORCAS)80,80,240
   80 IF(SENSE SWITCH 2)95,85
*AVOIDS COMMENT CARD TROUBLE BY INSPECTING FIRST RECORD
*  OF TAPE 2
   85 CALL TPINSP
*
*LOAD DATA
   95 IF(DUMDIP)99,100,99
   99 READ DIP DHGSUB,AFFSUB,OL,OLSUB,PER,MN,A1,B1,OM,OK,AKF,AKH,AAF,AAF
     12,CIN,CEX,C1,C2,TWT,A2,Q,FT,FTEMP,PSIINP,INOL,INDHG,INAFFL,INAAFL,
     2INAAF2,PSIOUT,TQT,NOL,NDHG,DWADD,TBADD,PSIN,XNORM,PUNCH,PRINT,NW,W
     3SUB,KPOWER,INPUT,NOINPT,LIMPRS,PRTALL,MAXMNO,MAXTMP,LMBULK,TBBULK,
     4KCHK1,KCHK2,KCHK3,TRANSF,TRANHL,TRANHU,NEWSET,QBAR,QOQBAR,NOGEOM
     5,STAGES
  100 READ DIP ACCMNO,ACCPRS,ACCTMP,ALLRUN,AUTOLS,AFF,BETA1,BETA2,CLOSS,
     1CLSMOD,DOUTE-TD+NNE-,DHTENT-*CTEL-MAJTEL
     2LT,HMULT,HEIGHT,KASE,KASTEP,LIMCHK,LMCHTO,LIMTRY,NDH,NAFF,NAFL,NLE
     3N,NCLOSS,NOPRT,NOSTGE,NCLSMD,NORING,NHMULT,NFMULT,LENGTH,PARPRT,PR
     4TSUM,PHISUM,PHIEX,P0,P0,P1,PI,P2,PTXOPI,PSXOPI,RNKIN,RNKOUT,ROUND,
     5RECTNG,RINGS,THICK,TOTLEN,TEXOTI,WIDTH,XOL,PEX,PTEX,PIN,PTIN,TIN,T
     6T+N,PSEXTTEXTTTEXTWTTWMAOT-,OTT*
     7NOQTOT,NOPSEXTNOPTEX,NOWTNOTTEXTDPT+N,DTT+N
     8EX,DW,DTTEX,COFHLM,COFHTB,EXHPLM,EXHPTB,EXHRLM,EXHRTB,COFFLM,COFFT
     9B,EXPFLM,EXPFTB,CASE,CASTEP,PTXOPI,PSXOPI,TEXOTI,GAS,HEADER,DHG
*
```

```
      KTRCRD=KTRCRD+1
*WAS DIP ERROR ENCOUNTERED
      IF(SENSE LIGHT 1)120,130
  120 PRINT 32032,KTRCRD
32032 FORMAT
      SPACE
  ABOVE DIP ERRORS OCURRED IN INPUT RECORD NO      -I.
      SPACE
      END OF FORMAT
      DEAD=1.
      GO TO 80
*IS JOB BEING PULLED (YES IF SS4 DOWN)
  130 IF(SENSE SWITCH 4)100,135
*NORMAL CONTINUATION   WAS AN ERROR PREVIOUSLY ENCOUNTERED
  135 IF(DEAD)150,150,140
*IS PROGRAM TO CALCULATE ANYWAY
  140 IF(ALLRUN)80,80,145
*HAS A NEWSET CASE FAILED
  145 IF(SENSE LIGHT 4)146,147
  146 SENSE LIGHT 4
      GO TO 100
  147 DEAD=0.
*CHECK STAGE LIMIT NOT EXCEEDED
  150 IF(100-NOSTGE)151,152,152
  151 DEAD=1.
      CALL NETERR(152,152)
      GO TO 80
*NORMAL SEQUENCE - CHECK IF POSSIBLE PARAMETRIC
  152 DO 160 N=1,8
      IF(KPARAM(N))160,160,155
*POSSIBLY PARAMETRIC
  155 MORCAS=1
      FSTPAR=1.
      KASESV=KASE
      KTPAR=0
      GO TO 165
  160 CONTINUE
*NOT PARAMETRIC
      GO TO 360
*PRE-PROCESSING FOR PARAMETRIC STUDIES
*SET RUNNING COUNTERS
  165 DO 190 K=1,8
      IF(DPARAM(K))180,170,180
  170 KPARMR(K)=0
      GO TO 190
  180 KPARMR(K)=KPARAM(K)-1
  190 CONTINUE
*CHECK NEED FOR UNIT CHANGES ON INCREMENTS
*   AFTER GENERAL TRANSFER
      DO 200 K=1,8
  200 DPARMI(K)=DPARAM(K)
      IF(FTIN)360,360,210
  210 DPARMI(1)=DPARMI(1)/144.
      DPARMI(5)=DPARMI(5)/144.
      DPARMI(6)=DPARMI(6)/144.
      GO TO 360
*WAS CASE JUST COMPLETED FIRST PARAMETRIC CASE
```

```
  240 IF(FSTPAR)250,270,250
*FIRST PARAMETRIC
  250 DO 260 K=1,8
  260 FPARMI(K)=BSO(K)
      FSTPAR=0.
*NORMAL PARAMETRIC CONTROL - CHECK COUNTERS
  270 KASE=KASE+1
      DO 290 K=1,4
      K=K
      KD=KONPAR(K,KOPT)
      IF(KPARMR(KD))290,290,280
*INCREMENT K-TH VARIABLE
  280 BSO(KD)=BSO(KD)+DPARMI(KD)
      KPARMR(KD)=KPARMR(KD)-1
      GO TO 310
  290 CONTINUE
*EXIT HERE MEANS PARAMETRIC STUDY FINISHED
*RESTORE INPUT VALUES OF MAJOR VARIABLES
      DO 300 L=1,8
  300 BSO(L)=FPARMI(L)
      KASE=KASESV
      MORCAS=0
      CALL RESET
*RETURN FOR NEW DATA
      GO TO 80
*NORMAL SEQUENCING - RESET RIGHTWARD COUNTERS
*  AND VARIABLES
  310 KM1=K-1
      IF(KM1)360,360,320
  320 DO 350 L=1,KM1
      KD=KONPAR(L,KOPT)
      IF(DPARAM(KD))340,350,340
  340 KPARMR(KD)=KPARAM(KD)-1
      BSO(KD)=FPARMI(KD)
  350 CONTINUE
*SR ALL FINISHED
  360 CONTINUE
      RETURN
      END(0,0,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
*RESET663  RESETS CERTAIN CALCULATED DATA FIELDS FOR
*GFP 663  GENERAL FLOW PASSAGE
*    S C SKIRVIN
*
      SUBROUTINE RESET
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI   (100 ),BSI    (11  ),BSO    (11  ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI    (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),
     4KPARAM(8   ),KPARMR(8   ),NDH    (100 ),NAFL   (100 ),NLEN   (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0     (100 ),P1     (100 ),
     7P2    (100 ),THICKD(100 ),TEXI   (100 ),XOLD   (100 ),BHIGH (12  ),
     8HEDDUM(12  ),GMASS (100 ),TW     (100 ),REYNO (100 ),FRIC  (100 ),
```

```
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102   )),(BSI   ,BG1(202   )),
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224   )),(CLOSSI,BG1(237   )),
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438   )),(DHD   ,BG1(539   )),
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739   )),(DPARMI,BG1(747   )),
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759   )),(FMULTI,BG1(768   )),
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968   )),(HEDDUM,BG1(974   )),
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087  )),(KPARMR,BG1(1095  )),
     8(KRSCON,BG1(1103  )),(NDH   ,BG1(1107  )),(NAFL  ,BG1(1207  )),
     9(NLEN  ,BG1(1307  )),(NCLOSS,BG1(1407  )),(NCLSMD,BG1(1507  ))
      EQUIVALENCE
     1(NHMULT,BG1(1607  )),(NFMULT,BG1(1707  )),(OLEND ,BG1(1808  )),
     2(OLENI ,BG1(1908  )),(PHISUM,BG1(2008  )),(PHIEX ,BG1(2108  )),
     3(P0    ,BG1(2208  )),(P1    ,BG1(2308  )),(P2    ,BG1(2408  )),
     4(TEXI  ,BG1(2508  )),(TW    ,BG1(2608  )),(XOLD  ,BG1(2708  )),
     5(XOL   ,BG1(2808  )),(REYNO ,BG1(2908  )),(FRIC  ,BG1(3008  )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
*END OF STORAGE MAP
*
      DIMENSION GRTMPI(3)
      EQUIVALENCE (GRTMPI,BSO(2))
*RESET TO ZERO
      DO 110 N=1,NOSTGE
      DHI(N)=0.
```

```
      OLENI(N)=0.
      AFFI(N)=0.
      CLSGEN(N)=0.
      FRIC(N)=0.
      CONVEC(N)=0.
      P0(N)=0.
      P1(N)=0.
      P2(N)=0.
  110 CONTINUE
      KASE=KASE+KASTEP
      IF(NEWSET)300,370,300
*DID CONVERGENCE TAKE PLACE
  300 IF(SENSE LIGHT 2)310,320
  310 DEAD=1.
      CALL NETERR(200,1)
      SENSE LIGHT 4
      GO TO 360
*REPLACE BSI WITH BSO
  320 CALL DSTRB1(BSO,11,BSI,0,0,KSIG)
      QBAR=QTOTD
*CHECK UNITS
      IF(FTIN)325,335,325
  325 IF(FTOUT)340,330,340
  330 TRAN1=144.
  332 PTIN=PTIN*TRAN1
      PTEX=PTEX*TRAN1
      PSEX=PSEX*TRAN1
      GO TO 340
  335 IF(FTOUT)337,340,337
  337 TRAN1=1./144.
      GO TO 332
  340 IF(RNKIN)355,345,355
  345 IF(RNKOUT)350,360,350
  350 M=-1
  351 CALL CONTMP(GRTMPI,3,GRTMPI,M)
      DO 354 L=1,3
      IF(9999.+GRTMPI(L))354,352,354
  352 GRTMPI(L)=0.
  354 CONTINUE
      GO TO 360
  355 IF(RNKOUT)360,356,360
  356 M=1
      GO TO 351
  360 NEWSET=0
  370 CONTINUE
      RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
*SETYLD63  SR TO SELECT VALUE OF DEPENDENT VARIABLE FOR
*  CURRENT ITERATION OR SET RESULTS FOR OUTPUTTING FROM
*  FOR GFP(ANP 663)
*FINAL SETUP IF I=0   OTHERWISE NORMAL ITERATION
*  PROCEDURE
*
      SUBROUTINE SETYLD(ID,GD)
*
*BEGIN STORAGE MAP
```

```
* * * MASTER GROUPING
       DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
      1BG(5474)
       EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
       COMMON BG
* * * END OF MASTER GROUPING
*BASIC OPTIONAL VARIABLES
       DIMENSION GRTMPI(3),GRTMPO(3)
       EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
      1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
      2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
      3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
      4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
      5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
      6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
       DIMENSION TW(100),BSI(11),BSO(11)
       EQUIVALENCE(TW,BG1(2608)),(NHOT,BG0(45)),(KOPT,BG0(32)),
      1(BSI,BG1(202)),(BSO,BG1(213)),(DELH,BG0(14)),(MAXTMP,BG0(79)),
      2(KDD,BG0(77)),(NOSTGE,BG0(47))
*END OF STORAGE MAP
*
       I=ID
       MAXTMP=MAXTMP
       KDD=KDD
       IF(KOPT-2)115,115,110
  110  IF(I)180,120,180
*CHECK IF STAGE SPECIFIED
  115  IF(MAXTMP)120,120,117
  117  TWMAXD=TW(MAXTMP)
       NHOT=MAXTMP
       GO TO 135
*TWMAX
  120  TWMAXD=0.
       DO 130 N=1,NOSTGE
       IF(TWMAXD-TW(N))125,125,130
  125  TWMAXD=TW(N)
       NHOT=N
  130  CONTINUE
  135  IF(I)140,200,140
  140  GD=TWMAXD
       GO TO 230
*ITERATION
  180  GD=BSO(KDD)
       GO TO 230
  200  CONTINUE
*REMAINDER OF OUTPUT SETUP
       DO 210 M=1,7
       IF(KOPT-2*M+1)210,220,210
  210  CONTINUE
*TEXD IS USER-SPECIFIED
       QTOTD=WD*DELH
*SET UP RATIOS
  220  PSPID=PSEXD/PIND
       PTPID=PEXD/PIND
       TXTID=TEXD/TIND
*SR FINISHED
  230  CONTINUE
```

```
      RETURN
      END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*SUMPRT63  SR TO PRINT SUMMARIZED OUTPUT FOR UP
*  TO 100 CASES FOR
*GFP 663  GENERAL FLOW PASSAGE
*    S C SKIRVIN
*
      SUBROUTINE SUMPRT
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI    (11   ),BSO    (11   ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI    (100 ),DPARAM(8    ),DPARMI(8    ),FMULTI(100 ),
     3FTABI (8    ),FPARMI(8    ),HTABI (6    ),HMULTI(100 ),KRSCON(4    ),
     4KPARAM(8    ),KPARMR(8    ),NDH    (100 ),NAFL   (100 ),NLEN   (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),PO     (100 ),P1     (100 ),
     7P2    (100 ),THICKD(100 ),TEXI   (100 ),XOLD   (100 ),BHIGH (12   ),
     8HEDDUM(12  ),GMASS (100 ),TW     (100 ),REYNO (100 ),FRIC   (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))
      EQUIVALENCE
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))
      EQUIVALENCE
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
     7          (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
     2 (TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
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     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
      EQUIVALENCE
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102  )),(BSI   ,BG1(202  )),
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224  )),(CLOSSI,BG1(237  )),
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438  )),(DHD   ,BG1(539  )),
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739  )),(DPARMI,BG1(747  )),
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759  )),(FMULTI,BG1(768  )),
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968  )),(HEDDUM,BG1(974  )),
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087 )),(KPARMR,BG1(1095 )),
     8(KRSCON,BG1(1103 )),(NDH    ,BG1(1107 )),(NAFL  ,BG1(1207 )),
     9(NLEN  ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(P0    ,BG1(2208 )),(P1    ,BG1(2308 )),(P2    ,BG1(2408 )),
     4(TEXI  ,BG1(2508 )),(TW    ,BG1(2608 )),(XOLD  ,BG1(2708 )),
     5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC  ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
```

```
*END OF STORAGE MAP
*
      KALCNO=KALCNO
      KGAS=KGAS
      KTEST=8-KALCNO/2
*SET UNITS   LENGTH
      KD1=1
      IF(FTOUT)120,120,110
  110 KD1=2
*TEMP
  120 KD2=1
      IF(RNKOUT)140,140,130
  130 KD2=2
  140 KRT=1
*CHECK NEED FOR UNIT CHANGES
      IF(FTOUT)170,170,150
*LENGTH
  150 DO 160 K=1,KALCNO
      SAVTAB(2,K)=SAVTAB(2,K)*144.
      SAVTAB(6,K)=SAVTAB(6,K)*144.
      SAVTAB(7,K)=SAVTAB(7,K)*144.
  160 CONTINUE
  170 IF(RNKOUT)180,180,200
*TEMPERATURE
  180 DO 190 K=1,KALCNO
      CALL CONTMP(SAVTAB(3,K),3,SAVTAB(3,K),-1)
  190 CONTINUE
*NORMAL CONTINUATION   PRINT UNIT HEADING
  200 CALL PRTUNT(2,KD1,KD2)
      GO TO(210,250,230),KRT
*START SUMMARY TABLE
  210 KL=1
      KU=KALCNO
      EXIT=1.
      IF(41-KALCNO)220,230,230
  220 KU=41
      EXIT=0.
  230 KD=KU-KL+1
      PRINT 32005,KD,PRTGAS(KGAS),KGAS,KSVTAB(1,KL),
     1KSVTAB(1,KU),(KSVTAB(1,K),SAVTAB(8,K),SAVTAB(2,K),
     2SAVTAB(7,K),SAVTAB(11,K),SAVTAB(6,K),SAVTAB(10,K),
     3K=KL,KU)
32005 FORMAT
      SPACE
   SUMMARY PRINTOUT FOR  -I POINTS  (GAS IS-X    -A, NO -I)
     (CASES     -I THRU     -I)
      SPACE
                WEIGHT       INLET       EXIT       PTEX/       EXIT       PSEX/
   CASE          FLOW        P-TOT       P-TOT       PTIN       P-STAT       PTIN
      SPACE
     -I         -1PE5       -0PF3         -F3       -F5          -F3        -F5
      REPEAT 1
      END OF FORMAT
*
      IF(KTEST)240,250,250
  240 KRT=2
      GO TO 200
```

```
  250 PRINT 32010,KD,PRTGAS(KGAS),KGAS,KSVTAB(1,KL),
     1KSVTAB(1,KU),(KSVTAB(1,K),SAVTAB(3,K),SAVTAB(4,K),
     2SAVTAB(12,K),SAVTAB(9,K),SAVTAB(5,K),KSVTAB(13,K),
     3K=KL,KU)
 32010 FORMAT
       SPACE
   SUMMARY PRINTOUT FOR  -I POINTS  (GAS IS-X    -A, NO -I)
     (CASES     -I THRU     -I)
       SPACE
              INLET     EXIT       TTEX/       HEAT        MAX AVE
   CASE       T-TOT     T-TOT       TTIN      ADDITION     SURF-TEMP AT STGE
       SPACE
     -I      -0PF1        -F1        -F5          -1PE5        -0PF1        -I
       REPEAT 1
       END OF FORMAT
*
       IF(EXIT)300,260,300
  260 KL=KU+1
       KRT=3
       IF(86-KALCNO)270,290,290
  270 IF(86-KU)290,290,280
  280 KU=86
       GO TO 200
  290 KU=KALCNO
       EXIT=1.
       GO TO 200
*FINISHED
  300 KALCNO=0
       RETURN
       END(0,0,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
CTWLT  00 A SR TO CALCULATE WALL TEMPS FOR LALMINAR OR TURBULENT FLOW
*  WITH OR WITHOUT ENTRANCE LENGTH EFFECTS
*GFP 663  GENERAL FLOW PASSAGE
*
      SUBROUTINE TWLT(IDENT)
*
*BEGIN STORAGE MAP
*GENERAL USEAGE
      DIMENSION
     1AFFI  (100 ),BSI    (11   ),BSO    (11   ),CLOSSI(100 ),CLSGEN(100 ),
     2CLSMDI(100 ),DHI    (100 ),DPARAM(8     ),DPARMI(8     ),FMULTI(100 ),
     3FTABI (8    ),FPARMI(8     ),HTABI (6     ),HMULTI(100 ),KRSCON(4    ),
     4KPARAM(8    ),KPARMR(8     ),NDH    (100 ),NAFL   (100 ),NLEN   (100 ),
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),PO     (100 ),P1     (100 ),
     7P2    (100 ),THICKD(100 ),TEXI   (100 ),XOLD   (100 ),BHIGH (12   ),
     8HEDDUM(12   ),GMASS (100 ),TW     (100 ),REYNO (100 ),FRIC   (100 ),
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP
      EQUIVALENCE
     1(AD    ,BG0(1    )),(ACCMNO,BG0(2    )),(ACCPRS,BG0(3    )),
     2(ACCTMP,BG0(4    )),(ALLRUN,BG0(5    )),(AUTOLS,BG0(6    )),
     3(BD    ,BG0(7    )),(BLANKS,BG0(8    )),(BETA1 ,BG0(9    )),
     4(BETA2 ,BG0(10   )),(CIN   ,BG0(11   )),(CEX   ,BG0(12   )),
     5(DEAD  ,BG0(13   )),(DELH  ,BG0(14   )),(DERIV ,BG0(15   )),
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```
      6(ENTRN ,BG0(16     )),(ENTRNC,BG0(17     )),(FD    ,BG0(18     )),
      7(FTIN  ,BG0(19     )),(FTOUT ,BG0(20     )),(FSTPAR,BG0(21     )),
      8(GOAL  ,BG0(22     )),(GAS   ,BG0(23     )),(HIN   ,BG0(24     )),
      9(ITRY  ,BG0(25     )),(KTRCRD,BG0(26     )),(KALCNO,BG0(27     ))
       EQUIVALENCE
      1(KTCHAD,BG0(28     )),(KTWADJ,BG0(29     )),(KTCHTO,BG0(30     )),
      2(KPOW  ,BG0(31     )),(KOPT  ,BG0(32     )),(KOSCIL,BG0(33     )),
      3(KCHOKE,BG0(34     )),(KASE  ,BG0(35     )),(KASTEP,BG0(36     )),
      4(LOC   ,BG0(37     )),(LIMCHK,BG0(38     )),(LMCHTO,BG0(39     )),
      5(LIMTRY,BG0(40     )),(MORCAS,BG0(41     )),(NSKPPR,BG0(42     )),
      6(NSKPHT,BG0(43     )),(NT    ,BG0(44     )),(NHOT  ,BG0(45     )),
      7(NOPRT ,BG0(46     )),(NOSTGE,BG0(47     )),(PARPRT,BG0(48     )),
      8(PRTSUM,BG0(49     )),(RNKIN ,BG0(50     )),(RNKOUT,BG0(51     )),
      9(SVACMN,BG0(52     )),(SVACPR,BG0(53     )),(TOTLND,BG0(54     ))
       EQUIVALENCE
      1(TRY0  ,BG0(55     )),(TRY1  ,BG0(56     )),(TRY2  ,BG0(57     )),
      2(TRY3  ,BG0(58     )),(TEST1 ,BG0(59     )),(TOTLEN,BG0(60     )),
      3(WHI   ,BG0(61     )),(WLO   ,BG0(62     )),(YIELD0,BG0(63     )),
      4(YIELD1,BG0(64     )),(YIELD2,BG0(65     )),(NOINPT,BG0(66     )),
      5(LIMPRS,BG0(67     )),(PRTALL,BG0(68     )),(OMAXD ,BG0(69     )),
      6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),
      7           (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(
      878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),
      9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))
       EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),
      1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))
      2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))
      3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),
      4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))
       EQUIVALENCE
      1(AFFD  ,BG1(2      )),(AFFI  ,BG1(102    )),(BSI   ,BG1(202    )),
      2(BSO   ,BG1(213    )),(BHIGH ,BG1(224    )),(CLOSSI,BG1(237    )),
      3(CLSGEN,BG1(337    )),(CLSMDI,BG1(438    )),(DHD   ,BG1(539    )),
      4(DHI   ,BG1(639    )),(DPARAM,BG1(739    )),(DPARMI,BG1(747    )),
      5(FTABI ,BG1(755    )),(FPARMI,BG1(759    )),(FMULTI,BG1(768    )),
      6(GMASS ,BG1(868    )),(HTABI ,BG1(968    )),(HEDDUM,BG1(974    )),
      7(HMULTI,BG1(987    )),(KPARAM,BG1(1087   )),(KPARMR,BG1(1095   )),
      8(KRSCON,BG1(1103   )),(NDH   ,BG1(1107   )),(NAFL  ,BG1(1207   )),
      9(NLEN  ,BG1(1307   )),(NCLOSS,BG1(1407   )),(NCLSMD,BG1(1507   ))
       EQUIVALENCE
      1(NHMULT,BG1(1607   )),(NFMULT,BG1(1707   )),(OLEND ,BG1(1808   )),
      2(OLENI ,BG1(1908   )),(PHISUM,BG1(2008   )),(PHIEX ,BG1(2108   )),
      3(P0    ,BG1(2208   )),(P1    ,BG1(2308   )),(P2    ,BG1(2408   )),
      4(TEXI  ,BG1(2508   )),(TW    ,BG1(2608   )),(XOLD  ,BG1(2708   )),
      5(XOL   ,BG1(2808   )),(REYNO ,BG1(2908   )),(FRIC  ,BG1(3008   )),
      6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
      7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
       DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
       EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
      1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
       EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
       EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
      1FTABI(3)),(EXPFTB,FTABI(4))
*
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```
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,FTABI(3)),
     1(EXPFTB,FTABI(4)),(ND,NOSTGE),(G,GMASS),(REAVG,REYNO),
     2(OMEX,OMEXI)
      DIMENSION G(100),REAVG(100),OMEX(100)
      DIMENSION AQPR(2)
      EQUIVALENCE(A,AQPR),(QPR,AQPR(2))
      DIMENSION TSTGR(13)
      EQUIVALENCE(VIP,TSTGR),(TSTP,TSTGR(2)),(VIM,TSTGR(3)),
     1(TSTM,TSTGR(4)),(VIMX,TSTGR(5)),(VIMN,TSTGR(6)),
     2(VI0,TSTGR(7)),(VI1,TSTGR(8)),(VI2,TSTGR(9)),(VI3,TSTGR(10)),
     3(VD0,TSTGR(11)),(VD1,TSTGR(12)),(VD2,TSTGR(13))
*END OF STORAGE MAP
*
      IF(IDENT)90,95,90
   90 PRINT 32000
32000 FORMAT
      SPACE 3
 **** WALL TEMP CALC (SR TWLT) HAS FULL FANTAN (ANP 542)
 **** ANALYSIS WITH TRANSITION AND ENTRANCE LENGTH EFFECTS.
 **** PROPERTY FUNCTIONS(R,ENFRMT,TFRMEN,VISC,PRN,TC) DE-
 **** TERMINE WHICH GASES CAN BE HANDLED.
      END OF FORMAT
*
      GO TO 460
*
*INITIALIZE
   95 TAVG=TEXI(1)
      CALL FPRNT(4HTEXI,TEXI,ITRY,NOSTGE,KCHK3)
      SUMLEN=0.
      TINI=TIND
```

```
*SET STAGE LOOP
      DO 450 N=1,ND
      DO 98 L=1,13
      VFACT=1.
   98 TSTGR(L)=0.
      TLO=0.
      THI=1.E+5
      TAVGL=(TINI+TEXI(N))/2.
      REYNO(N)=G(N)*DHI(N)*12./VISC(TAVGL,GAS)
*SET  KTRAN TO INDICATE TRANSITION
*SET  NOSKIP=0 IF NO FILM TEMP CALC NEEDED
      NOSKIP=0
      IF(REYNO(N)-TRANHL)102,102,110
*LAMINAR
  102 KTRAN=-1
      IF(LMBULK)140,105,140
  105 NOSKIP=1
      GO TO 140
  110 IF(REYNO(N)-TRANHU)120,130,130
*TRANSITION
  120 KTRAN=0
      EQUIVALENCE(KTBULK,TBBULK)
      IF(LMBULK*KTBULK)140,125,140
  125 NOSKIP=1
      GO TO 140
*TURBULENT
  130 KTRAN=+1
      IF(TBBULK)140,135,140
  135 NOSKIP=1
  140 CONTINUE
      IF(N 1)180,180,190
  180 SDELH=DELH*PHISUM(N)
      GO TO 200
  190 SDELH=DELH*(PHISUM(N)-PHISUM(N-1))
  200 IF(OLENI(N))210,210,215
  210 TW(N)=TEXI(N)
      CONVEC(N)=0.
      GO TO 420
  215 CONTINUE
      CALL FPRNT(5HSDELH,SDELH,N,1,KCHK3)
      CON1=4.*OLENI(N)/(GMASS(N)*PHIEX(N)*DHI(N))
      CALL FPRNT(4HCON1,CON1,N,1,KCHK3)
      SUMLEN=SUMLEN+OLENI(N)
      VISCAV=VISC(TEXI(N),GAS)
      KTPRS=1
*ITERATION RETURN
  220 TFACT=VFACT*TEXI(N)/TAVG
      FREYNO=REYNO(N)*TFACT
      CALL FPRNT(6HFREYNO,FREYNO,KTPRS,1,KCHK3)
      CALL FPRNT(4HTAVG,TAVG,KTPRS,1,KCHK3)
      STGPRN=PRN(TAVG,GAS)
*SELECT N(RE) RANGE
      IF(KTRAN)240,290,260
*
*LAMINAR
  240 KRT=1
  245 STGNNU=HTABI(1)*(STGPRN**HTABI(2))*(FREYNO**HTABI(3))
```

```
*IS ENTRANCE LENGTH EFFECT (ELE) WANTED
      IF(ENTRN)255,255,250
*ELE WANTED
  250 STGNNU=(STGNNU**3+1.225*FREYNO*STGPRN*(DHI(N)/SUMLEN))**.33333
  255 GO TO(320,300),KRT
*
*TURBULENT
  260 KRT=1
  265 STGNNU=HTABI(4)*(STGPRN**HTABI(5))*(FREYNO**HTABI(6))
*IS ELE WANTED
      IF(ENTRN)285,285,270
*ELE WANTED
  270 IF(SUMLEN/DHI(N)-FREYNO**.25)280,285,285
  280 STGNNU=1.5*STGNNU*(DHI(N)/SUMLEN)**.16
  285 GO TO(320,310),KRT
*
*TRANSITIONAL
  290 KRT=2
      SVTRL=TRANHL
      TRANHL=TRANHL*TFACT
      SVTRU=TRANHU
      TRANHU=TRANHU*TFACT
      SVNRE=FREYNO
      FREYNO=TRANHL
      GO TO 245
  300 PRN103=STGPRN**.3333
      ETA0=STGNNU/(FREYNO*PRN103)
      ETA0L=LOGF(ETA0)
      FREYNO=TRANHU
      GO TO 265
  310 ETA1=STGNNU/(FREYNO*PRN103)
      FREYNO=SVNRE
      A=((TRANHU*TRANHL)/(TRANHL-TRANHU))*(TRANHU*
     1(LOGF(ETA1)-ETA0L)/(-(TRANHL-TRANHU))-(HTABI(6)-1.))
      B=(A/TRANHU+HTABI(6)-1.)/TRANHU
      C=ETA0L-A/TRANHL-B*TRANHL
      ETA=EXPF(A/FREYNO+B*FREYNO+C)
      STGNNU=ETA*FREYNO*PRN103
      TRANHL=SVTRL
      TRANHU=SVTRU
*
*NUSSELT NO CALCULATED
  320 CONVEC(N)=STGNNU*TC(TAVG,GAS)/DHI(N)
     1*HMULTI(N)
      CALL FPRNT(6HSTGNNU,STGNNU,KTPRS,1,KCHK3)
      CALL FPRNT(6HCONVEC,CONVEC(N),N,1,KCHK3)
      IF(KTPRS-2)325,360,360
  325 TWN=TEXI(N)+SDELH/(CON1*CONVEC(N))
      CALL FPRNT(3HTWN,TWN,N,1,KCHK3)
*TEST FOR SIMULTANEOUS BULK CORRELATIONS
      IF(NOSKIP)330,420,330
  330 IF(KTPRS-1)336,332,336
*FIRST PASS
  332 VI0=TWN
      VI1=TWN
      VI2=TWN
*STEP ITERATION COUNTER AND CALC FILM TEMP
```

```
  334 KTPRS=KTPRS+1
      TAVG=(TWN+TEXI(N))/2.
      VFACT=VISCAV/VISC(TAVG,GAS)
      GO TO 220
*CONVERGENCE TEST
  336 IF(ABSF(TWN-VI1)-ACCTMP)420,420,350
*NOT CONVERGED - IS COUNTER EXCEEDED
  350 IF(LIMPRS-KTPRS)352,354,354
*EXCEEDED
  352 TW(N)=TEXI(N)
  353 CALL NETERR(190,N)
      SENSE LIGHT 2
      GO TO 422
*NOT EXCEEDED
  354 CONTINUE
*IS JOB BEING PULLED ON TIME
      IF(SENSE SWITCH 4)356,358
  356 CALL NETERR(520,N)
      GO TO 460
*NOT PULLED
  358 IF(KTPRS-2)380,380,334
*NORMAL CONTINUATION
  360 ENTRY=CONVEC(N)*CON1*(TWN-TEXI(N))
      CALL FPRNT(5HENTRY,ENTRY,KTPRS,1,KCHK3)
      TESTD=SDELH-ENTRY
      CALL FPRNT(5HTESTD,TESTD,KTPRS,1,KCHK3)
*TEST FOR BOUNDS
      IF(TESTD)368,420,362
*HAS POS BOUND BEEN SET
  362 IF(TSTP)366,364,366
*SET POS BOUND
  364 TSTP=TESTD
      VIP=VI2
      GO TO 374
*TEST POS BOUND
  366 IF(TSTP-TESTD)374,374,364
*HAS NEG BOUND BEEN SET
  368 IF(TSTM)372,370,372
*SET NEG BOUND
  370 TSTM=TESTD
      VIM=VI2
      GO TO 374
*TEST NEG BOUND
  372 IF(TESTD-TSTM)374,374,370
*CAN MAX-MIN BE ESTABLISHED
  374 IF(TSTP*TSTM)376,378,376
*SET MAX-MIN
  376 VIMX=MAX1F(VIP,VIM)
      VIMN=MIN1F(VIP,VIM)
      CALL FPRNT(6HMAXMIN,VIMX,KTPRS,2,KCHK3)
  378 CONTINUE
      CALL FPRNT(6HBND+/-,VIP,KTPRS,4,KCHK3)
      IF(KTPRS-3)325,382,402
*SECOND ITERATION
  380 VD0=ENTRY
      VI1=TWN
      VI2=TWN
```

```
      GO TO 334
*THIRD ITERATION
  382 VD1=ENTRY
      CALL EXTRAP(0,0,VI0,VD0,VI1,VD1,TWN,SDELH,2)
  383 VI3=TWN
*HAVE MAX-MIN LIMITS BEEN SET
  384 IF(VIMX*VIMN)386,394,386
*TEST AGAINST MAX-MIN BOUNDS
  386 IF(TWN-VIMN)390,390,388
  388 IF(VIMX-TWN)390,390,392
*DICHOTIMIZE
  390 TWN=(VIMX+VIMN)/2.
*RETURN FOR NEXT PASS
  392 VI2=TWN
      CALL FPRNT(5HVI0-3,VI0,KTPRS,4,KCHK3)
      CALL FPRNT(3HTWN,TWN,N,1,KCHK3)
      GO TO 336
*TEST AGAINST GROSS LIMITS
  394 IF(THI-TWN)396,396,398
*REDUCE
  396 TWN=.5*(THI+MAX1F(VI0,VI1))
      GO TO 392
  398 IF(TWN-TLO)400,400,392
*INCREASE
  400 TWN=MIN1F(VI0,VI1)/2.
      GO TO 392
*FOURTH AND SUBSEQUENT PASSES
  402 VD2=ENTRY
      CALL FPRNT(5HVD0-2,VD0,KTPRS,3,KCHK3)
      CALL EXTRAP(VI0,VD0,VI1,VD1,VI2,VD2,TWN,SDELH,3)
      VI0=VI1
      VI1=VI2
      VD0=VD1
      VD1=VD2
      GO TO 383
*
*NORMAL CONVERGED CONTINUATION
  420 TW(N)=TWN
*IS JOB BEING PULLED ON TIME
  422 IF(SENSE SWITCH 4)356,425
*IS THIS LAST STAGE
  425 IF(ND-N)460,460,440
*DELETE 3284-3285
  440 TAVG=TEXI(N+1)
  450 TINI=TEXI(N)
*
*FINISHED
  460 CONTINUE
      RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
CUNCHKE00  SR TO ALLEVIATE CHOKES FOR
*GFP 663  GENERAL FLOW PASSAGE
* S C SKIRVIN
*
      SUBROUTINE UNCHKE
*
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```
*BEGIN STORAGE MAP                                                          3300 663
*GENERAL USEAGE                                                             3301 663
      DIMENSION                                                             3302 663
     1AFFI  (100 ),BSI   (11  ),BSO   (11  ),CLOSSI(100 ),CLSGEN(100 ),    3303 663
     2CLSMDI(100 ),DHI   (100 ),DPARAM(8   ),DPARMI(8   ),FMULTI(100 ),    3304 663
     3FTABI (8   ),FPARMI(8   ),HTABI (6   ),HMULTI(100 ),KRSCON(4   ),    3305 663
     4KPARAM(8   ),KPARMR(8   ),NDH   (100 ),NAFL  (100 ),NLEN  (100 ),    3306 663
     5NCLOSS(100 ),NCLSMD(100 ),NRINGD(100 ),NHMULT(100 ),NFMULT(100 ),    3307 663
     6OLENI (100 ),PHISUM(100 ),PHIEX (100 ),P0    (100 ),P1    (100 ),    3308 663
     7P2    (100 ),THICKD(100 ),TEXI  (100 ),XOLD  (100 ),BHIGH (12  ),    3309 663
     8HEDDUM(12  ),GMASS (100 ),TW    (100 ),REYNO (100 ),FRIC  (100 ),    3310 663
     9CONVEC(100),DPINT(100),OMEXI(100),PRTGAS(9)                           3311 663
      DIMENSION PSEXI(100),PDYEXI(100),PEXI(100)                            3312 663
*BG0 NON-SUBSCRIPTED, BG1 SINGLE, BG2 DOUBLE, BG3 CLEANUP                   3313 663
      EQUIVALENCE                                                           3314 663
     1(AD    ,BG0(1     )),(ACCMNO,BG0(2     )),(ACCPRS,BG0(3     )),      3315 663
     2(ACCTMP,BG0(4     )),(ALLRUN,BG0(5     )),(AUTOLS,BG0(6     )),      3316 663
     3(BD    ,BG0(7     )),(BLANKS,BG0(8     )),(BETA1 ,BG0(9     )),      3317 663
     4(BETA2 ,BG0(10    )),(CIN   ,BG0(11    )),(CEX   ,BG0(12    )),      3318 663
     5(DEAD  ,BG0(13    )),(DELH  ,BG0(14    )),(DERIV ,BG0(15    )),      3319 663
     6(ENTRN ,BG0(16    )),(ENTRNC,BG0(17    )),(FD    ,BG0(18    )),      3320 663
     7(FTIN  ,BG0(19    )),(FTOUT ,BG0(20    )),(FSTPAR,BG0(21    )),      3321 663
     8(GOAL  ,BG0(22    )),(GAS   ,BG0(23    )),(HIN   ,BG0(24    )),      3322 663
     9(ITRY  ,BG0(25    )),(KTRCRD,BG0(26    )),(KALCNO,BG0(27    ))       3323 663
      EQUIVALENCE                                                           3324 663
     1(KTCHAD,BG0(28    )),(KTWADJ,BG0(29    )),(KTCHTO,BG0(30    )),      3325 663
     2(KPOW  ,BG0(31    )),(KOPT  ,BG0(32    )),(KOSCIL,BG0(33    )),      3326 663
     3(KCHOKE,BG0(34    )),(KASE  ,BG0(35    )),(KASTEP,BG0(36    )),      3327 663
     4(LOC   ,BG0(37    )),(LIMCHK,BG0(38    )),(LMCHTO,BG0(39    )),      3328 663
     5(LIMTRY,BG0(40    )),(MORCAS,BG0(41    )),(NSKPPR,BG0(42    )),      3329 663
     6(NSKPHT,BG0(43    )),(NT    ,BG0(44    )),(NHOT  ,BG0(45    )),      3330 663
     7(NOPRT ,BG0(46    )),(NOSTGE,BG0(47    )),(PARPRT,BG0(48    )),      3331 663
     8(PRTSUM,BG0(49    )),(RNKIN ,BG0(50    )),(RNKOUT,BG0(51    )),      3332 663
     9(SVACMN,BG0(52    )),(SVACPR,BG0(53    )),(TOTLND,BG0(54    ))       3333 663
      EQUIVALENCE                                                           3334 663
     1(TRY0  ,BG0(55    )),(TRY1  ,BG0(56    )),(TRY2  ,BG0(57    )),      3335 663
     2(TRY3  ,BG0(58    )),(TEST1 ,BG0(59    )),(TOTLEN,BG0(60    )),      3336 663
     3(WHI   ,BG0(61    )),(WLO   ,BG0(62    )),(YIELD0,BG0(63    )),      3337 663
     4(YIELD1,BG0(64    )),(YIELD2,BG0(65    )),(NOINPT,BG0(66    )),      3338 663
     5(LIMPRS,BG0(67    )),(PRTALL,BG0(68    )),(OMAXD ,BG0(69    )),      3339 663
     6(OMAX,BG0(70)),(OMAX1,BG0(71)),(KOPTH,BG0(72)),                       3340 663
     7          (DMCONV,BG0(75)),(KDI,BG0(76)),(KDD,BG0(77)),(TRYMAX,BG0(3341 663
     878)),(MAXTMP,BG0(79)),(LMBULK,BG0(80)),(TBBULK,BG0(81)),              3342 663
     9(KCHK1,BG0(1)),(KCHK2,BG0(7)),(KCHK3,BG0(18)),(KGAS,BG0(82))          3343 663
      EQUIVALENCE(PDYIN,BG0(73)),(PDYEX,BG0(74)),(OMINLT,BG0(83)),          3344 663
     1(OMEXIT,BG0(84)),(DPIN,BG0(85)),(DPEX,BG0(86))                        3345 663
     2,(TRANSF,BG0(87)),(TRANHL,BG0(88)),(TRANHU,BG0(89))                   3346 663
     3,(NEWSET,BG0(90)),(KTPAR,BG0(91)),(KTOTPR,BG0(92)),(QBAR,BG0(93)),3347 663
     4(QOQBAR,BG0(94)),(NOGEOM,BG0(95))                                     3348 663
      EQUIVALENCE                                                           3349 663
     1(AFFD  ,BG1(2     )),(AFFI  ,BG1(102   )),(BSI   ,BG1(202   )),      3350 663
     2(BSO   ,BG1(213   )),(BHIGH ,BG1(224   )),(CLOSSI,BG1(237   )),      3351 663
     3(CLSGEN,BG1(337   )),(CLSMDI,BG1(438   )),(DHD   ,BG1(539   )),      3352 663
     4(DHI   ,BG1(639   )),(DPARAM,BG1(739   )),(DPARMI,BG1(747   )),      3353 663
     5(FTABI ,BG1(755   )),(FPARMI,BG1(759   )),(FMULTI,BG1(768   )),      3354 663
     6(GMASS ,BG1(868   )),(HTABI ,BG1(968   )),(HEDDUM,BG1(974   )),      3355 663
     7(HMULTI,BG1(987   )),(KPARAM,BG1(1087  )),(KPARMR,BG1(1095  )),      3356 663
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     8(KRSCON,BG1(1103 )),(NDH    ,BG1(1107 )),(NAFL   ,BG1(1207 )),
     9(NLEN   ,BG1(1307 )),(NCLOSS,BG1(1407 )),(NCLSMD,BG1(1507 ))
      EQUIVALENCE
     1(NHMULT,BG1(1607 )),(NFMULT,BG1(1707 )),(OLEND ,BG1(1808 )),
     2(OLENI ,BG1(1908 )),(PHISUM,BG1(2008 )),(PHIEX ,BG1(2108 )),
     3(PO    ,BG1(2208 )),(P1     ,BG1(2308 )),(P2     ,BG1(2408 )),
     4(TEXI  ,BG1(2508 )),(TW     ,BG1(2608 )),(XOLD   ,BG1(2708 )),
     5(XOL   ,BG1(2808 )),(REYNO ,BG1(2908 )),(FRIC   ,BG1(3008 )),
     6(CONVEC,BG1(3108)),(DPINT,BG1(3208)),(OMEXI,BG1(3308))
     7,(PRTGAS,BG1(3408)),(PSEXI,BG1(3417)),(PDYEXI,BG1(3517))
*OPEN AT 3617, KEEP OPEN UNTIL 3700
      DIMENSION KONOPT(2,10),KONPAR(4,13),SAVTAB(13,100),KSVTAB(13,100)
      EQUIVALENCE(KONOPT,KUP,BG2),(KONPAR,BG2(21)),
     1(SAVTAB,KSVTAB,BG2(73))
*OPEN 1373
      EQUIVALENCE(THICKD,BG3(2)),(NRINGD,BG3(103)),(PEXI,BG3(203))
*
      EQUIVALENCE(COFFLM,FTABI),(EXPFLM,FTABI(2)),(COFFTB,
     1FTABI(3)),(EXPFTB,FTABI(4))
*
*BASIC OPTIONAL VARIABLES
      DIMENSION GRTMPI(3),GRTMPO(3)
      EQUIVALENCE(PIN,BSI),(TIN,BSI(2)),(TEX,BSI(3)),(TWMAX,
     1BSI(4)),(PSEX,BSI(5)),(PEX,BSI(6)),(W,BSI(7)),(QTOT,
     2BSI(8)),(PIND,BSO),(TIND,BSO(2)),(TEXD,BSO(3)),(TWMAXD,
     3BSO(4)),(PSEXD,BSO(5)),(PEXD,BSO(6)),(WD,BSO(7)),(QTOTD,
     4BSO(8)),(PSXOPI,BSI(9)),(PTXOPI,BSI(10)),(TEXOTI,BSI(11)),
     5(PSPID,BSO(9)),(PTPID,BSO(10)),(TXTID,BSO(11)),
     6(GRTMPI,BSI(2)),(GRTMPO,BSO(2))
*
      EQUIVALENCE(COFHLM,HTABI),(EXHPLM,HTABI(2)),(EXHRLM,
     1HTABI(3)),(COFHTB,HTABI(4)),(EXHPTB,HTABI(5)),(EXHRTB,
     2HTABI(6))
      EQUIVALENCE(DPTIN,DPARAM),(DTTIN,DPARAM(2)),(DTTEX,DPARAM(3)),
     1(DTWMAX,DPARAM(4)),(DPSEX,DPARAM(5)),(DPTEX,DPARAM(6)),(DW,DPARAM(
     27)),(DQTOT,DPARAM(8)),(NOPTIN,KPARAM),
     3(NOTTIN,KPARAM(2)),(NOTTEX,KPARAM(3)),(NOTWMX,NTWMAX,NOTWA,
     4KPARAM(4)),(NOPSEX,KPARAM(5)),(NOPTEX,KPARAM(6)),(NOW,KPARAM(7)),
     5(NOQTOT,KPARAM(8))
*
* * * MASTER GROUPING
      DIMENSION BG0(100),BG1(3700),BG2(1372),BG3(302),
     1BG(5474)
      EQUIVALENCE(BG0,BG),(BG1,BG(101)),(BG2,BG(3801)),(BG3,BG(5173))
      COMMON BG
* * * END OF MASTER GROUPING
*
      EQUIVALENCE(KCHK11,KCHK2)
*END OF STORAGE MAP
*
      KDI=KDI
*IS THIS ENTRY FOR CHOKE OR FOR YIELD IMPROVEMNT
      IF(KCHOKE)90,200,90
   90 CONTINUE
*HAS THE CHOKE LIMIT BEEN EXCEEDED
      IF(LIMCHK-KTCHAD)100,100,110
*HAS THIS CHOKE LIMIT BEEN PREVIOUSLY EXCEEDED
```

```
  100 IF(SENSE LIGHT 2)105,106
  105 SENSE LIGHT 2
      GO TO 300
*EXCEEDED
  106 CALL NETERR(160,4)
      SENSE LIGHT 2
      GO TO 300
*CONTINUE
  110 KTWTRY=0
      KWTTOT=0
      IF(TRYMAX)114,114,112
  112 WHI=MIN1F(WHI,TRYMAX)
  114 IF(KDI-1)120,116,120
  116 WLO=MAX1F(WLO,BSO(KDI))
      GO TO 150
  120 WHI=MIN1F(WHI,BSO(KDI))
*
  150 KTCHAD=KTCHAD+1
  160 CONTINUE
      OMTRY=MIN1F(.9*OMINLT,.5*OMAX1)
      K2=KCHOKE
      IF(K2-1)170,170,180
  170 TD=TIND
      PD=PIND
      GO TO 190
  180 TD=TEXI(K2-1)
      PD=PEXI(K2-1)
  190 CONTINUE
      CALL FPRNT(6HCHKVAL,BSO(KDI),KCHOKE,1,KCHK11)
      AFF1=AFFI(K2)
      IF(KDI-1)194,192,194
  192 PIND=PRSFUN(AFF1,WD,TD,OMTRY,GAS)
      GO TO 196
*FLOW FUNCTION AT M=0.1
  194 WD=FLWFUN(AFF1,PD,TD,OMTRY,GAS)
  196 CONTINUE
      CALL FPRNT(6HNEWFLO,BSO(KDI),KCHOKE,1,KCHK11)
  200 CONTINUE
      IF(BSO(KDI)-WLO)202,202,201
  201 IE(WHI-BSO(KDI))202,202,205
  202 BSO(KDI)=(WHI+WLO)/2.
  205 IF(KDI-1)206,214,206
*SETUP FOR NEW WEIGHT FLOW
  206 DO 208 M=1,5
      IF(KOPT-2*M+1)208,210,208
  208 CONTINUE
*TEXD USER SPECIFIED
      GO TO 212
*QTOTD USER-SPECIFIED
  210 TEXD=TMPENT(QTOTD/WD+HIN,GAS,-1)
  212 DELH=TMPENT(TEXD,GAS,1)-HIN
      DO 213 N=1,NOSTGE
      GMASS(N)=WD/AFFI(N)
      TEXI(N)=TMPENT(PHISUM(N)*DELH+HIN,GAS,-1)
  213 CONTINUE
  214 CONTINUE
      CALL FPRNT(6HNEWFLO,BSO(KDI),KTWTRY,1,KCHK11)
```

```
      KTWTRY=KTWTRY+1
      CALL DPFRLT(0)
*DID CHOKE OCCUR
      IF(KCHOKE)250,250,215
*CHOKE OCCURRED
  215 IF(KDI-1)218,216,218
  216 WLO=MAX1F(WLO,BSO(KDI))
      GO TO 219
  218 WHI=BSO(KDI)
  219 KTCHAD=KTCHAD+1
*IS LIMIT EXCEEDED FOR SINGLE TRY
      IF(LIMCHK-KTCHAD)106,220,220
  220 IF(KDI-1)230,160,230
*DID CHOKE MOVE DOWNSTREAM
  230 IF(KCHOKE-K2)200,200,160
*NO CHOKE
  250 IF(KDI-1)251,260,251
  251 WLO=MAX1F(WLO,BSO(KDI))
*IS MAX MACH NO MORE THAN OMAX1
      CALL FPRNT(6HMAXMNO,OMAX,KTWTRY,1,KCHK11)
*ADJUST TO HIGHER FLOW IF MACH NO NOT ABOVE OMAX1
  255 IF(OMAX1-OMAX)270,256,256
*DO WHI AND WLO DIFFER BY MORE THAN 1 PART IN 10-5
  256 IF(ABSF((WHI-WLO)/WHI)-1.E-5)270,270,257
*HAVE 5 TRIES BEEN MADE WITH OMAX1
  257 IF(5 KTWTRY)258,258,200
*DECREASE OMAX1
  258 OMAX1=.8*OMAX1
      KWTTOT=KWTTOT+KTWTRY
      KTWTRY=0
      CALL FPRNT(6HNEWMAX,OMAX1,KWTTOT,1,KCHK11)
      GO TO 255
*UPDATE WHI FOR PRESSURE
  260 WHI=MIN1F(WHI,BSO(KDI))
*FINISHED
  270 KCHOKE=0
  300 CONTINUE
      RETURN
      END(0,0,0)
```

```
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*GAM-D       CP/CV
*  AIR(1)(APEX 527), H2(4)(DC 61-1-47), NEON(DC 58 6-205)
*  HELIUM(HE) APPROXIMATED FROM GE DESIGN DATA,G513.1,7/31/58
      FUNCTION GAM(TD,GAS)
      DIMENSION TMPLOW(4),TMPHI(4),A(6,4),TITLE(1),COFAIR(6),
     1COFH2(6),COFN(6),COFHE(6)
      EQUIVALENCE(COFAIR,A),(COFH2,A(7)),(COFN,A(13)),(COFHE,A(19))
      TABLE TMPLOW(500.,180.,0.,0.),TMPHI(2900.,4400.,1.+20,1.+20)
      TABLE
     1COFAIR(1.3817485,1.0502408E-04,-1.6293016E-07,6.5723018E-11,
     2-8.6452813E-15,0.)
     3,COFH2(1.44,-.03545E-03,0.,0.,0.,0.)
     4,COFN(1.651,0.,0.,0.,0.,0.)
     5,COFHE(1.667,0.,0.,0.,0.,0.)
     6,TITLE(3HGAM)
      EXCEED=0.
      KGAS=GAS
      KGAST=KGAS
      T=TD
      GO TO (100,10,10,400,10,600,10,10,900),KGAS
   10 CALL NOPROP(TITLE,KGAS)
*AIR
  100 KGASD=1
      KGAST=1
      GO TO 2000
*H2
  400 KGASD=2
      GO TO 2000
*HE
  600 KGASD=4
      GO TO 2000
*NEON
  900 KGASD=3
*CHECK LIMITS
 2000 IF(T TMPLOW(KGASD))2005,2020,2010
 2005 T=TMPLOW(KGASD)
      GO TO 2016
 2010 IF(TMPHI(KGASD)-T)2015,2020,2020
 2015 T=TMPHI(KGASD)
 2016 EXCEED=1.
 2020 GAM=
     1     A(1,KGASD)+T*(A(2,KGASD)+T*(A(3,KGASD)+T*(A(4,KGASD)
     2+T*(A(5,KGASD) T*A(6,KGASD)))))
*WAS TEMP LIMIT EXCEEDED
 3000 IF(EXCEED)3010,3020,3010
 3010 CALL LMPROP(TITLE,TMPLOW(KGASD),TMPHI(KGASD),TD,KGAST)
*FINISHED
 3020 CONTINUE
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*LMPROP  SR TO PRINT COMMENT WHEN TEMP LIMITS FOR
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225T

```
*  FOR PROPERTY FUNCTIONS ARE EXCEEDED
*USEAGE - CALL LMPROP(NAME(HOLLERITH),TLOW,THIGH,T TRIED,
*  KGAS)
*    S C SKIRVIN
*
      SUBROUTINE LMPROP(NAME,TLOW,THIGH,TRIED,KGAS)
*
      DIMENSION PRTGSL(9)
      TABLE PRTGSL(54HAIR   N2    CO2   H2    O2    HE    ARGON FREON NE
     1ON   )
      WRITE OUTPUT TAPE 3,32000,NAME,PRTGSL(KGAS),
     1TLOW,THIGH,TRIED
*LMPROP
32000 FORMAT
      SPACE
 * * * * * *
 *-X    -A TMP-LIMITS FOR-X    -A ARE   -F0 AND   -F0 (DEG R)
 *  T=   -F0 WAS TRIED, BUT NEAREST LIMIT TEMP WAS USED.
 * * * * * *
      SPACE
      END OF FORMAT
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*NOPROP  A SR FOR PRINTOUT REGARDING MISSING
*  GAS PROPERTIES
*USEAGE - CALL NOPROP(HOLLERITH(MAX 6 CHARAC),KGAS(FIXED
*  POINT))
*
      SUBROUTINE NOPROP(COM,KGAS)
      TABLE PRTGSL(54HAIR   N2    CO2   H2    O2    HE    ARGON FREON NE
     1ON   )
      DIMENSION PRTGSL(9)
      WRITE OUTPUT TAPE 3,32000,COM,PRTGSL(KGAS),KGAS
32000 FORMAT
      SPACE 2
 * * * * * * *
 *GAS PROPERTY-X    -A NOT PRESENT FOR-X    -A(NO -I). AIR VALUE ASSUMED
 * * * * * * *
      END OF FORMAT
*
      RETURN
      END(0,1,0)
*PRN-D      PRANDTL NO
*AIR(1)(APEX 527),NEON(9)(DC 58-6-205),H2(4)(DC 61 1-47)
*  HELIUM(HE) APPROXIMATED FROM GE DESIGN DATA,G513.1,7/31/58
      FUNCTION PRN(TD,GAS)
      DIMENSION TMPLOW(4),TMPHI(4),A(6,4),TITLE(1),COFAIR(6),
     1COFH2(6),COFN(6),COFHE(6)
      EQUIVALENCE(COFAIR,A),(COFH2,A(7)),(COFN,A(13)),(COFHE,A(19))
      TABLE TMPLOW(400.,180.,460.,860.),TMPHI(2400.,3600.,2800.,1.+20),
     1COFAIR(9.970762E-1,-9.64461E-4,1.042408E-6,-4.920634E-10,
     21.046379E-13,-7.659388E-18)
     3,COFH2(9.361730E-1,-6.592753E-4,4.622303E-7, 8.246998E 11,
     44.312456E-16,0.)
     5,COFN(1.2773,1.8416E-3,2.1338E-6,-1.1991E-9,3.2599E-13,
     6-3.4314E-17),
```

```
     7COFHE(.72,0.,0.,0.,0.,0.),TITLE(3HPRN)
      EXCEED=0.
      KGAS=GAS
      KGAST=KGAS
      T=TD
      GO TO (100,10,10,400,10,600,10,10,900),KGAS
   10 CALL NOPROP(TITLE,KGAS)
*AIR
  100 KGASD=1
      KGAST=1
      GO TO 2000
*H2
  400 KGASD=2
      GO TO 2000
*HE
  600 KGASD=4
      GO TO 2000
*NEON
  900 KGASD=3
*CHECK LIMITS
 2000 IF(T TMPLOW(KGASD))2005,2020,2010
 2005 T=TMPLOW(KGASD)
      GO TO 2016
 2010 IF(TMPHI(KGASD)-T)2015,2020,2020
 2015 T=TMPHI(KGASD)
 2016 EXCEED=1.
 2020 PRN=
     1     A(1,KGASD)+T*(A(2,KGASD)+T*(A(3,KGASD)+T*(A(4,KGASD)
     2+T*(A(5,KGASD) T*A(6,KGASD)))))
*WAS TEMP LIMIT EXCEEDED
 3000 IF(EXCEED)3010,3020,3010
 3010 CALL LMPROP(TITLE,TMPLOW(KGASD),TMPHI(KGASD),TD,KGAST)
*FINISHED
 3020 CONTINUE
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
CR       USEAGE   R(NUMBER INDICATES THE GAS)
      FUNCTION R(GAS)
      NGAS=GAS
      GO TO(1,2,3,4,5,6,7,8,9),NGAS
CGAS =1,AIR
    1 R=53.35
      GO TO 100
CGAS =2,NITROGEN(2)
    2 R=55.112
      GO TO 100
CGAS =3,CARBON DIOXIDE
    3 R=35.082
      GO TO 100
CGAS =4,HYDROGEN(2)
    4 R=765.873
      GO TO 100
CGAS =5,OXYGEN(2)
    5 R=48.25
      GO TO 100
CGAS =6,HELIUM
```

```
    6 R=385.711
      GO TO 100
CGAS =7,ARGON
    7 R=38.654
      GO TO 100
CGAS =8,FREON
    8 R=15.1484
      GO TO 100
CNEON
    9 R=76.6
  100 RETURN
      END(0,1,0)
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
CTC-D
C  AIR(1)(APEX 527), H2(4)(DC 61-1-47), NEON(DC 58 6-205)
C  HELIUM(HE) APPROXIMATED FROM GE DESIGN DATA,G513.1,7/31/58
      FUNCTION TC(TD,GAS)
      DIMENSION TMPLOW(4),TMPHI(4),A(6,4),TITLE(1),COFAIR(6),
     1COFH2(6),COFN(6),COFHE(6)
      EQUIVALENCE(COFAIR,A),(COFH2,A(7)),(COFN,A(13)),(COFHE,A(19))
      TABLE TMPLOW(100.,180.,460.,660.),TMPHI(3800.,3600.,2800.,1760.)
      TABLE
     1COFAIR(-2.6073866E-08,8.3542893E-10,-2.970625E-13,8.7701180E-17,
     2-14.653178E-21,10.162822E-25)
     3,COFH2(1.7508833E-07,4.9717133E-09,-7.9260066E-13,-4.7760366E-16,
     41.5687925E-19, 4.6325091E-24)
     5,COFN(-2.9599169E-07,2.421E-09,1.902E-12,9.9E-16,-2.6303335E-19,
     62.74866667E-23)
     7,COFHE(1.13E-06,1.77E-09,0.,0.,0.,0.)
     8,TITLE(2HTC)
      EXCEED=0.
      KGAS=GAS
      KGAST=KGAS
      T=TD
      GO TO (100,10,10,400,10,600,10,10,900),KGAS
   10 CALL NOPROP(TITLE,KGAS)
CAIR
  100 KGASD=1
      KGAST=1
      GO TO 2000
CH2
  400 KGASD=2
      GO TO 2000
CHE
  600 KGASD=4
      GO TO 2000
CNEON
  900 KGASD=3
CHECK LIMITS
 2000 IF(T TMPLOW(KGASD))2005,2020,2010
 2005 T=TMPLOW(KGASD)
      GO TO 2016
 2010 IF(TMPHI(KGASD)-T)2015,2020,2020
 2015 T=TMPHI(KGASD)
 2016 EXCEED=1.
 2020 TC=
```

```
     1      A(1,KGASD)+T*(A(2,KGASD)+T*(A(3,KGASD)+T*(A(4,KGASD)
     2+T*(A(5,KGASD) T*A(6,KGASD)))))
*WAS TEMP LIMIT EXCEEDED
 3000 IF(EXCEED)3010,3020,3010
 3010 CALL LMPROP(TITLE,TMPLOW(KGASD),TMPHI(KGASD),TD,KGAST)
*FINISHED
 3020 CONTINUE
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
CTMPENT-A  FUNCTION TO CALC ENTHALPY FROM TEMP OR
*  TEMP FROM ENTHALPY
*AIR(1),N2(2),CO2(3),H2(4),O2(5),HE(6),ARGON(7),FREON(8),NEON(9)
*AIR - BASED ON ANPD AIR PROPERTIES DATA BOOK(APEX )
*H2 BASED ON NASA DATA(KING TN D-275, 441 PSIA)
*  HELIUM(HE) APPROXIMATED FROM GE DESIGN DATA,G513.1,7/31/58
*    S C SKIRVIN
*USEAGE - FUNCTION TMPENT(TEMP OR ENTHALPY,GAS SELECTOR,
*  MODE) - (GAS SELECTOR IS FLOATING POINT)
*    MODE= 1 MEANS ENTHALPY FROM TEMP, MODE=-1 MEANS
*    TEMP FROM ENTHALPY (TEMPS IN DEG R)
*
      FUNCTION TMPENT(VD,GAS,MODE)
*
      TABLE ATGR(
     10.,.240176,-8.005646-6,1.192176-8, 2.917016-12,2.340132-16,0.,0.,
     20.,0.,0.,0.,0.,0.,0.,0.,
     30.,0.,0.,0.,0.,0.,0.,0.,
     459938.,4460.08 3,-1657.-6,904.55-9,-190.42-12,14.381-15,0.,0.,
     50.,0.,0.,0.,0.,0.,0.,0.,
     60.,0.,0.,0.,0.,0.,0.,0.,
     70.,0.,0.,0.,0.,0.,0.,0.,
     80.,0.,0.,0.,0.,0.,0.,0.,
     9-5.39,.2484,0.,0.,0.,0.,0.,0.)
      TABLE CTDGR(
     1-1.6011292-5,3.576528-8, 1.1668064 11,1.170066-15,0.,0.
     20.,0.,0.,0.,0.,0.,
     30.,0.,0.,0.,0.,0.,
     4-3314.-6,2713.65-9,-761.68-12,71.905-15,0.,0.,
     50.,0.,0.,0.,0.,0.,
     60.,0.,0.,0.,0.,0.,
     70.,0.,0.,0.,0.,0.,
     80.,0.,0.,0.,0.,0.,
     90.,0.,0.,0.,0.,0. )
      TABLE AHGR(
     10.,4.183639,4.440606-4,-3.284583-6,3.74104-9,-1.3759926-12,0.,0.,
     20.,0.,0.,0.,0.,0.,0.,0.,
     30.,0.,0.,0.,0.,0.,0.,0.,
     4-39828.,11855. 4,-1228.2 8,66.243-12,-.5738-16,-.09086 20,0.,0.,
     50.,0.,0.,0.,0.,0.,0.,0.,
     60.,0.,0.,0.,0.,0.,0.,0.,
     70.,0.,0.,0.,0.,0.,0.,0.,
     80.,0.,0.,0.,0.,0.,0.,0.,
     90.,0.,0.,0.,0.,0.,0.,0.)
      DIMENSION ATGR(8,9),CTDGR(6,9),AHGR(8,9),ATS(8),
     1CTDS(6),AHS(8)
      EQUIVALENCE(AT,ATS),(BT,ATS(2)),(CT,ATS(3)),(DT,ATS(4)),
```

```
     1(ET,ATS(5)),(FT,ATS(6)),(GT,ATS(7)),(HT,ATS(8)),(CTD,CTDS),
     2(DTD,CTDS(2)),(ETD,CTDS(3)),(FTD,CTDS(4)),(GTD,CTDS(5)),
     3(HTD,CTDS(6)),(AH,AHS),(BH,AHS(2)),(CH,AHS(3)),(DH,AHS(4)),
     4(EH,AHS(5)),(FH,AHS(6)),(GH,AHS(7)),(HH,AHS(8))
*
      V=VD
      T=V
      KGAS=GAS
      MD=MODE
*CHECK IF FIRST ENTRY FOR MACHINE RUN
      IF(KGAS-6)20,410,20
   20 IF(IFIRST-9999)90,30,90
*CHECK IF SAME GAS AS LAST ENTRY
   30 IF(KGAS-LSTGAS)90,40,90
*CHECK IF SAME MODE AS LAST ENTRY
   40 IF(LSTMDE-MD)50,50,90
*IF +,SET INVERSION CONSTANTS   IF MINUS, ALREADY HAVE
*  CONSTANTS - IF ZERO, NO CHANGE FROM PREVIOUS ENTRY
   50 IF(MD)300,310,310
*FIRST CHECK IF GAS PRESENT
   90 IF(9 KGAS)100,95,95
   95 GO TO(110,100,100,110,100,100,100,100,110),KGAS
*ERROR COMMENT
  100 CALL NOPROP(6HTMPENT,KGAS)
      KGAS=1
*SELECT GAS CONSTANTS
  110 DO 120 L=1,8
      ATS(L)=ATGR(L,KGAS)
  120 CONTINUE
      IF(MD)130,310,310
*SET CONSTANTS FOR INVERSION
  130 DO 150 L=1,8
*FIRST CUT COEFFICIENTS
      AHS(L)=AHGR(L,KGAS)
      IF(6 L)150,140,140
*DERIVATIVE COEFFICIENTS
  140 CTDS(L)=CTDGR(L,KGAS)
  150 CONTINUE
*
*BEGIN CALCULATIONS
*FIRST ENTRY FOR ITERATION - FIRST TEMP CUT
  300 T=V*(V*(V*(V*(V*(V*(V*HH GH)+FH)+EH)+DH)+CH) BH)+AH
*SET ENTHALPY FIRST CUT
  310 HO=T*(T*(T*(T*(T*(T*(T*HT+GT)+FT)+ET)+DT)+CT)+BT)+AT
      IF(MD)320,340,340
*IF POS, ONLY WANTED ENTHALPY AND IS THRU
  320 HO=HO-V
      DHDTO=T*(T*(T*(T*(T*(T*HTD+GTD)+FTD)+ETD)+DTD)
     1+CTD)+BT
      TMPENT=T-HO/DHDTO
      IF(ABSF(TMPENT T)-.049999)350,350,330
*NEW PASS
  330 T=TMPENT
      GO TO 310
*FINISHED, MODE=1 FIRST
  340 TMPENT=HO
*MODE=-1
```

```
  350 CONTINUE
*SET SAVER TRIGGERS
      IFIRST=9999
      LSTGAS=KGAS
      LSTMDE=MD
      GO TO 400
  410 IF(MD)430,400,420
*HE
  420 TMPENT=1.242*V
      GO TO 400
  430 TMPENT=.805*V
*FINISHED
  400 CONTINUE
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*VISC-D VISCOSITY-LBM/SEC-FT
*  AIR(1)(APEX 527), H2(4)(DC 61-1-47), NEON(DC 58 6-205)
*  HELIUM(HE) APPROXIMATED FROM GE DESIGN DATA,G513.1,7/31/58
      FUNCTION VISC(TD,GAS)
      DIMENSION TMPLOW(4),TMPHI(4),COFVIS(6,4),A(6,4)
      EQUIVALENCE(A,COFVIS)
      TABLE TMPLOW(500.,180.,460.,660.),TMPHI(2900.,4400.,2800.,1760.),
     1COFVIS(23.25E-07,.21365E 07,-5.004E-12,6.967E-16,-2.588E-20,
     20.,
     30.,10.8264E-09,-1.96298E 12,.16358E-15,0.,0.,
     43.5412E-07,5.5814E-08,-4.3736E-11,2.6390E-14,-8.1457E-18,
     59.7400E-22,8.40E-06,11.8E-09,0.,0.,0.,0.),TITLE(4HVISC)
*
      EXCEED=0.
      KGAS=GAS
      T=TD
      GO TO (100,10,10,400,10,600,10,10,900),KGAS
   10 CALL NOPROP(TITLE,KGAS)
*AIR
  100 KGASD=1
      GO TO 2000
*H2
  400 KGASD=2
      GO TO 2000
*HE
  600 KGASD=4
      GO TO 2000
*NEON
  900 KGASD=3
*CHECK LIMITS
 2000 IF(T TMPLOW(KGASD))2005,2020,2010
 2005 T=TMPLOW(KGASD)
      GO TO 2016
 2010 IF(TMPHI(KGASD)-T)2015,2020,2020
 2015 T=TMPHI(KGASD)
 2016 EXCEED=1.
 2020 VISC=A(1,KGASD)+T*(A(2,KGASD)+T*(A(3,KGASD)+T*(A(4,KGASD)
     1+T*(A(5,KGASD) T*A(6,KGASD)))))
*WAS TEMP LIMIT EXCEEDED
 3000 IF(EXCEED)3010,3020,3010
 3010 CALL LMPROP(TITLE,TMPLOW(KGASD),TMPHI(KGASD),TD,KGAS)
```

```
*FINISHED
 3020 CONTINUE
      RETURN
      END(0,1,0)
```

7

```
* * * * * * * * * * * * * * * * * * * * * * * * * *
*AMACH
CUSEAGE AMACH(INITIAL GUESS,W/A,P,T,ACCURACY(FRACTIONAL),GAS)
      FUNCTION AMACH(OMACHB,G,P,T,PER,GAS)
      OMACHD=OMACHB
    5 GAMY=GAM(T,GAS)
      C1=(GAMY-1.0)/2.0
      C2=(GAMY+1.0)/(2.0*(GAMY 1.0))
      C3=(G/P)*SQRTF(R(GAS)*T/(32.17*GAMY))
   10 VAR=1.0+C1*OMACHD**2
      F=(C3*VAR**C2) OMACHD
      FPRIME=C3*(GAMY+1.0)*OMACHD/(2.0*VAR**(1.0-C2))-1.0
      OMACH=OMACHD-F/FPRIME
      IF(OMACH-.99)20,30,30
   20 IF(ABSF((OMACH OMACHD)/OMACH)-PER)30,25,25
   25 OMACHD=OMACH
      GO TO 10
   30 AMACH=OMACH
      RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * * *
CCONTMP  SR TO CONVERT NON-ZERO TEMPS FROM R TO F OR VICE VERSA
*  SETS ZERO R TEMPS = -9999.
*NEGATIVE TEMPS ARE ASSUMED TO BE IN DEG F
*    11/23/60
*    S C SKIRVIN
*USEAGE-CALL CONTMP(SOURCE TABLE,FINAL TABLE,NO OF
*    ENTRIES,MODE OF CHANGE)
*MODE.  =+1 F TO R, =-1 R TO F
      SUBROUTINE CONTMP(ST,NO,ET,MODE)
      DIMENSION ST(2),ET(2)
      IF(MODE)100,100,110
  100 KRT=1
      GO TO 120
  110 KRT=2
  120 DO 190 M=1,NO
      IF(ST(M))180,140,160
  140 GO TO(150,190),KRT
  150 ET(M)=-9999.
      GO TO 190
  160 GO TO(170,180),KRT
  170 ET(M)=ST(M)-460.
      GO TO 190
  180 ET(M)=ST(M)+460.
  190 CONTINUE
*FINISHED
  200 CONTINUE
      RETURN
      END(0,0,0)
* * * * * * * * * * * * * * * * * * * * * * * * * *
CDSTRB1  A SR FOR SPOTTING AND DISTRIBUTION WITHOUT UNIT
*CHANGES
* * COMNET(ANP 622) * *
```

```
* S C SKIRVIN
*  USEAGE   CALL DSTRB1(SOURCE TABLE,NO. OF SOURCE
*ENTRIES,RECEIVING TABLE,DISTRIBUTING VARIABLE(FIXED POINT),
*CONTROL(FIXED POINT),SIGNAL IF DISTRIBUTION DONE)
*  CONTROL,=0 NON ZERO POINT-FOR-POINT SHIFT,=1 TAKE
*DISTRIBUTE ENTRIES ONE AT A TIME,=2 TAKE DISTRIBUTE
*ENTRIES TWO AT A TIME AND DISTRIBUTE FROM SOURCE
*INTO RECEIVER.
*  SIGNAL,=0 IF NO DISTRIBUTION,=1 IF DISTRIBUTION.
* S C SKIRVIN   9/20/60
      SUBROUTINE DSTRB1(SOURCE,NOSOR,RECEIV,KDISTR,ITYPE,KSIG)
      DIMENSION SOURCE(500),RECEIV(500),KDISTR(1000)
      KSIG=0
      IF(ITYPE)100,200,100
*NOT SIMPLE TRANSFER OF NON-ZERO QUANTITIES
  100 IF(1 NOSOR)110,120,120
*TEST IF KDISTR PRESENT FOR NON-SIMPLE TRANSFER
  110 IF(KDISTR(1))230,230,120
  120 DO 190 N=1,1000,ITYPE
*TEST IF FINISHED
      IF(KDISTR(N))230,230,130
  130 KL=KDISTR(N)
      KSIG=1
*TEST IF POINT-FOR POINT SHIFT OR DISTRIBUTION
      IF(ITYPE-1)180,180,140
*DISTRIBUTION
  140 KU=KDISTR(N+1)
      DO 170 K=KL,KU
*TEST IF SINGLE-ENTRY OR MULTIPLE ENTRY SOURCE
      IF(NOSOR-1)150,150,160
*SINGLE ENTRY
  150 RECEIV(K)=SOURCE(1)
      GO TO 170
*MULTIPLE-ENTRY
  160 RECEIV(K)=SOURCE(KL)
  170 CONTINUE
      GO TO 190
*POINT-FOR POINT SHIFT
  180 RECEIV(KL)=SOURCE(1)
*LOOP END
  190 CONTINUE
      GO TO 230
*SIMPLE TRANSFER
  200 DO 220 N=1,NOSOR
*TEST TO INSURE NON-ZERO SHIFT
      IF(SOURCE(N))210,220,210
  210 RECEIV(N)=SOURCE(N)
  220 CONTINUE
*SUBROUTINE END
  230 RETURN
      END(0,1,0)
* * * * * * * * * * * * * * * * * * * * * * * * *
CDYPRSGAS
      FUNCTION DYPRS(G,P,T,AMACH,GAS)
C  CALCULATES COMPRESSIBLE DYNAMIC PRESS IN PSI OR
C    PSF, DEPENDING ON CONSISTENT INPUT UNITS
C  USEAGE   DYPRS(MASS VEL,TOTAL PRESS,TOTAL TEMP,MACH
```

```
C     NO,GAS SELECTOR)
       GAMA=GAM(T,GAS)
       DYPRS=(R(GAS)*(G**2*T/P)*(1.+(GAMA 1.)/2.*
      1AMACH**2)**(1./(GAMA-1.)))/64.34
       RETURN
       END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*EXTRAP  A SR TO DO 2 OR 3-POINT EXTRAPOLATION
*  S C SKIRVIN
*    3/21/61
*USEAGE - CALL EXTRAP(X0,Y0,X1,Y1,X2,Y2,X3(NEXT TRY),
*  Y3(DESIRED YIELD),NO(2 OR 3, WHETHER 2 OR 3 POINT
*  FIT WANTED))
*MODEL - (Y-B)**2=4.*F(X-A) FOR 3-POINT, Y=AX+B
*  FOR 2-POINT
*    AUTOMATICALLY DOES 2-POINT WITH X1,Y1,X2,Y2, IF
*      DIVIDE CHECK ENCOUNTERED DURING 3 PT FIT
*
       SUBROUTINE EXTRAP(X0,Y0,X1,Y1,X2,Y2,X3,Y3,NO)
*
*SELECT FIT
       IF(NO-2)300,200,100
*3-POINT
  100  Y2M0=Y2-Y0
       Y2P0=Y2+Y0
       Y1M0=Y1-Y0
       Y1P0=Y1+Y0
       X2M0=X2-X0
       X1M0=X1-X0
       B=(Y2M0*Y2P0*X1M0-Y1M0*Y1P0*X2M0)/
      1(2.*(Y2M0*X1M0 Y1M0*X2M0))
       IF DIVIDE CHECK 200,110
  110  FT4=(Y2M0*Y2P0 2.*B*Y2M0)/X2M0
       IF DIVIDE CHECK 200,120
  120  A=X2 ((Y2-B)**2/FT4)
       IF DIVIDE CHECK 200,130
  130  X3=A ((Y3-B)**2/FT4)
       GO TO 300
*2-POINT
  200  X3=((X2-X1)/(Y2-Y1))*(Y3 Y2)+X2
*FINISHED
  300  CONTINUE
       RETURN
       END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
CFLWFUN  A FUNCTION WHICH EVALUATES THE COMPRESSIBLE FLOW FUNCTION
*  IN TERMS OF TOTAL PROPERTIES - UNITS ARE INCH-BASED AND DEG R
       FUNCTION FLWFUN(AFF,P,T,OM,GAS)
       GAMA=GAM(T,GAS)
       FLWFUN   =AFF       *OM*P        *SQRTF((32.17*
      1GAMA)/(R(GAS)*T          ))/((1.+((GAMA-1.)/2.)*OM**2)
      2**((GAMA+1.)/(2.*(GAMA-1.))))
       RETURN
       END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*FPRNT       SUBROUTINE TO PRINT FLOATING POINT VAR.
```

```
      DIMENSION V(500)
      IF(K)5,5,10
    5 IF(SENSE SWITCH 5)10,20
   10 WRITE OUTPUT TAPE 3,1000,B,J,(V(K),K=1,N)
 1000 FORMAT(6H0     A6,I3/(1P4E15.5))
   20 RETURN
      END(0,1,0)
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
LOSS    SR TO CALCULATE NON-FRICTIONAL TOTAL PRESSURE LOSSES
   THIS VERSION HAS ONLY INCOMPRESSIBLE EXPANSION AND
   CONTRACTION LOSSES BASED ON DF56AGT588(EXP) AND
   DF56AGT468(CONTRAC)
     J E STANKEVICZ

      SUBROUTINE LOSS(A1,A2,L,DIMA,DIMB,DIMC,THETA,CLOSS)

  USEAGE  (A1=STA 1 AREA,A2=STA 2 AREA,L=TYPE OF
      LOSS,NEXT 4 VARIABLES CAN HAVE VARIOUS USES,
      CLOSS=CALCULATED COEFFICIENT)
 2000 FORMAT
      SPACE
  LOSS SUBROUTINE HAS MAX SELECTION OF 4 IN THIS VERSION.
   PROGRAM ASKED FOR -I. CHECK WITH J STANKEVICZ OR
    S SKIRVIN FOR LATER, EXPANDED VERSION.
      SPACE
      END OF FORMAT
      IF(L 4)10,10,20
   10 GO TO (1,2,3,4),L
  1 INDICATES CONTRACTION BASED ON Q1
    1 SIG=A2/A1
      PSI=1.0-((2.0+SIG)/5.1415927)*SQRTF(1.0-SIG)
      CLOSS=((1.0/PSI-1.0)/SIG)**2
      GO TO 100
  2 INDICATES CONTRACTION BASED Q2
    2 SIG=A2/A1
      PSI=1.0-((2.0+SIG)/5.1415927)*SQRTF(1.0-SIG)
      CLOSS=(1.0/PSI 1.0)**2
      GO TO 100
  3 INDICATES EXPANSION BASED ON Q1
    3 CLOSS=(1.0-A1/A2)**2
      GO TO 100
  4 INDICATES EXPANSION BASED ON Q2
    4 CLOSS=(A2/A1-1.0)**2
      GO TO 100
   20 WRITE OUTPUT TAPE 3,32000,L
      SENSE LIGHT 2
      CLOSS=0.
  100 RETURN
      END(0,1,0)
 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
NTERR622  SR TO PRINT ERROR COMMENTS FOR
 * COMNET(ANP 622) * *
 S C SKIRVIN
  10/6/60
      SUBROUTINE NETERR(N,LOC)
      WRITE OUTPUT TAPE 3,32000,N,LOC
 2000 FORMAT
```

```
      SPACE 2
 * * * * *
 * CALCULATION TERMINATED BY TYPE   -I ERROR AT LOC -I * * *
 * * * * *
      END OF FORMAT
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
CPOWER3   A SR TO CARRY OUT INTEGRATION OF POWER PROFILES. NOT SAME CALL
*  STATEMNT AS POWER2A, BUT IS STRIPPED FOR MINIMUM MEMORY AND DOES NOT
*  PUNCH, PRINT, OR NORMALIZE POWER PROFILES
C  USEAGE   CALL POWER3(TRAILING EDGE FACTORS, ACCUMULATED SUM,
C    NO OF STAGES,STAGE LENGTHS, ENTRANCE POWER, MIDPOINT POWER,
C    EXIT POWER)
      SUBROUTINE POWER3(Q,A2,MN,OLL,P0,P1,P2)
      DIMENSION A2(100),Q(100),OLL(100),          P0(100),
     1P1(100),P2(100)
      EQUIVALENCE (DELTA,FACNRM),(SIGMA,MSTPRT),(DELTA,ADUM)
      SIGMA=0.
      DELTA=0.
   10 DO 50 I=1,MN
      DELTA=DELTA+OLL(I)
      A2(I)=(OLL(I)/6.)*(P0(I) 4.*P1(I)+P2(I))
      SIGMA=SIGMA+A2(I)
C     50 CALCULATES TRAILING EDGE TO AVERAGE
   50 Q(I)=P2(I)*OLL(I)/A2(I)
  160 DO 190 I=1,MN
      ADUM=A2(I)/SIGMA
      IF(I 1)170,170,180
  170 A2(I)=ADUM
      GO TO 190
  180 A2(I)=ADUM+A2(I-1)
  190 CONTINUE
  395 RETURN
      END(0,0,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*PRSFUN  CALCULATES TOT PRES CORRESPONDING TO
*  GIVEN FLOW AREA, WT. FLOW, TOT TEMP, MACH NO, AND GAS
      FUNCTION PRSFUN(A,W,T,OM,GAS)
      GAMA=GAM(T,GAS)
      PRSFUN=(W/(OM*A))*SQRTF((R(GAS)*T/(32.17*GAMA))
     1*(1. OM**2*(GAMA-1.)/2.)**((GAMA+1.)/(GAMA-1.)))
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*PSTAT   FUNCTION TO CALCULATE STATIC PRESSURE
C  COMPRESSIBLE FLOW STATIC PRESSURE
*  USEAGE   PSTAT(TOT PRES,TOT TEMP,MACH NO,GAS SELECTOR(FP))
      FUNCTION PSTAT(P,T,OM,GAS)
      GAMA=GAM(T,GAS)
      PSTAT=P/((1.+((GAMA-1.)/2.)*OM**2)**(GAMA/(GAMA-1.)))
      RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
CTPINSP  A SR TO INSPECT THE FIRST RECORD ON TAPE 2
*  IF DIP-DATA CARD, BACKSPACES TAPE 2
*  IF NOT A DIP-DATA CARD, WILL OUTPUT ON TAPE 3
```

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```
*A ONE OR ZERO IN COL 1 INDICATES COMMENT CARD
      SUBROUTINE TPINSP
      DIMENSION REMAIN(11)
      READ INPUT TAPE 2,32000,TEST,(REMAIN(N),N=1,11)
32000 FORMAT(1A6,11A6)
B     AMASK=770000000000
B     CMASK=170000000000
B     BMASK=760000000000
B     ATEST=TEST*AMASK
*TEST FOR ZERO CONTROL
B     CTEST=ATEST*CMASK
      IF(CTEST)100,300,100
*TEST FOR ONE CONTROL
B 100 BTEST=ATEST*BMASK
      IF(BTEST)200,300,200
*DIP-CARD
  200 BACKSPACE 2
      GO TO 400
*COMMENT CARD
  300 WRITE OUTPUT TAPE 3,32000,TEST,(REMAIN(N),N=1,11)
  400 RETURN
      END(0,1,0)
*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
*XPRNT     SUBROUTINE TO PRINT INTEGER VAR.
      SUBROUTINE XPRNT(B,V,J,N,K)
      DIMENSION V(500)
      IF(K)5,5,10
    5 IF(SENSE SWITCH 5)10,20
   10 WRITE OUTPUT TAPE 3,1000,B,J,(V(K),K=1,N)
 1000 FORMAT(6H0     A6,I3/(7I10))
   20 RETURN
      END(0,0,0)
```

```
*STHA -THIS PROGRAM IS A MODIFICATION OF THE IBM 709
       COUNT   700
*FORTRAN STH ROUTINE. IT IS ESSENTIALLY A MODICATION
*OF J. A. DELANEY 704 STHA USING 709 STH. PROGRAM
*MODIFICATIONS BY R.A. PASTORE  NOV. 1960.
       REM
       REM
       ENTRY (STH)
       ENTRY (STHM)
       ENTRY RESTO
       ENTRY LINES
       ENTRY PAGES
       ENTRY NEWSET
       ENTRY HDING
       ENTRY NOHEAD
       ENTRY COLUMN
       ENTRY BOTTOM
       ENTRY ANPIPM
       ENTRY NOPAGE
       REM
       REM
       REM
       REM
       REM
 STHA  TTR   STH1
IND72  PZE
HDP    PZE 1                    ZERO FOR NO PAGE PRINTOUT         036
NP     PZE ,0,1                                                   037
HDN    PZE                      NEXT PAGE HEADING IND             038
CHHD   PZE                      CHANGE HEADING INDICATOR          039
D52    PZE ,0,53                                                  040
D53    PZE ,0,54                                                  041
D54    PZE ,0,55                                                  042
BINHD  OCT 376060606060                                           043
       BCD 1                                                      044
       REP 1,19                                                   045
 STH1  CLA   D(2)                                                 046
       STO   BOTLS
       CAL TIP8
       SLW   ANPIPM                                               061
STH18  CAL TOSTH
       SLW STH1                                                   063
       STZ NLLFT                                                  064
       STZ HDC                                                    065
 STHB  CLA   1,4               BUFFER ADDRESS,0,WORD COUNT        066
       STA WRBF1                INITIALIZE
       STA WRBF2-1              WRRF ROUTINE                      068
       STA GET1+1                                                 069
       STA   BUFNW                                                070
       STD NWDS
       SXD X4,4                                                   071
       SXD X2,2                                                   075
       SXD X1,1                                                   076
```

```
GET1    PXD    ,0
        LDQ
        LGL 6
        PAX ,2
        STO CONT
        SUB D(48)
        TZE PBL
        ADD D(32)
        TZE PPL
        TXH ILLGL,2,8
        TRA SET,2
PBL     LXA D(3),2
        TRA PNUM
OUT     LXD X1,1
        LXD X2,2
        LXD X4,4
BACK    TRA 2,4
*P1   PROCESS CONTROL 1
P1      CLA BOTLS
        TZE *+3
        STZ BOTLS
        TRA P1.2
        CLA HDC
        TZE P1.2                  WRITE HEADING
        TSX WRHD,4                AT BOTTOM IF
        PZE                       CALLED FOR
P1.2    TSX HDTST,4               TEST FOR HEADING
        CLA R                     IS PAGE RESTORED
        TZE P1.3                  NO
        LXA D(3),2                MAKE CONTROL BLANK FOR YES
        STZ R
P1.3    TSX WRBF1,4
        TRA OUT
*PPL PROCESS PLUS
PPL     LXA D(5),2
        TSX WRBF2,4
        TRA OUT
*P8 PROCESS CONTROL 8
P8      CLA NLLFT
        TZE P8.5
        CLA HDC
        TZE P8N
        LXD NLLFT,1               NUMBER OF LINES LEFT TO A
        TXL IS1,1,2
        TXI *+1,1,-2
        TSX WR1WD,4
        PZE 1
        TIX *-2,1,2
IS1     TXL    WR81,1,1
        TSX WR1WD,4
D(0)    PZE
WR81    LXA    D(3),2
        TSX WRBF1,4
P8.7    STZ NLLFT
        CLA LPP
        STO NL
        TRA OUT
```

```
       REM                                                      STHA 111
       REM    WRITE 1 WORD ROUTINE.                             STHA 112
       REM    TSX    WR1WD,4                                    STHA 113
       REM    PZE    N                                          STHA 114
       REM    WHERE N = 0,1,2 FOR BLANK,ZERO,OR FOUR.           STHA 115
       REM                                                      STHA 116
 WR2   PZE    1WD                                               STHA 117
 WR1WD CLA    WR2                                               STHA 118
       SUB    1,4                                               STHA 119
       STA    *+2                                               STHA 120
       SXA    WR3,4                                             STHA 121
       TSX    WRITE,4                                           STHA 122
       PZE      ,0,1                                            STHA 123
 WR3   AXT      ,4                                              STHA 124
       TRA    2,4                                               STHA 125
P8N    TSX WRBF2,4                                              STHA 126
       TRA P8.7                                                 STHA 127
P8.5   LXA D(1),2                                               STHA 128
       TRA P1                                                   STHA 129
*ELFT ENOUGH LINES LEFT                                         STHA 130
*TRA1,4 FOR NO                                                  STHA 131
*TRA2,4 FOR YES                                                 STHA 132
*CALL                                                           STHA 133
*     TSX ELFT,4                                                STHA 134
ELFT   CAL VECT,2                                               STHA 135
       ANA DMSK              GET NUMBER OF LINES                STHA 136
       CAS NLLFT             ENOUGH                             STHA 137
       TRA 1,4                                                  STHA 138
       TRA 2,4                                                  STHA 139
       TRA 2,4                                                  STHA 140
*WRHD WRITE TH CURRENT HEADING                                  STHA 141
*CALL                                                           STHA 142
*     TSX WRHD,4                                                STHA 143
*     ZER 0 OR 1             BOT OR TOP                         STHA 144
WRHD   SXD WSV1,1                                               STHA 145
       SXD WSV4,4                                               STHA 146
       CLA BINHD                                                STHA 147
       STO SBNHD                                                STHA 148
       CLA TOPHD                                                STHA 149
       STO BINHD                                                STHA 150
       SXD WSV2,2                                               STHA 151
       CLA 1,4                                                  STHA 152
       PAX ,1                                                   STHA 153
ADRHD  CAL A                 1ST WORD OF HEADING                STHA 154
       ANA MSK                                                  STHA 155
       ORA M8,1              INSERT 1 OR 8                      STHA 156
ADHD   SLW A                                                    STHA 157
       LXA D(20),1                                              STHA 158
       CLA IND72             IS PRINT 72 COL                    STHA 159
       TNZ *+2                                                  STHA 160
       TXI *+1,1,-8          YES REDUCE WORDS BY 8              STHA 161
       CLA 1,4               GET CONTROL   IS THIS TOP          STHA 162
       TZE NPG               NO                                 STHA 163
       CLA HDP               YES   TEST FOR PRINTING PAGE       STHA 164
       TZE NPG               NO                                 STHA 165
       TSX OTOD,4            YES   GET BCI PAGE                 STHA 166
       TRA CPYLP               241                              STHA 167
```

```
 NPG    TRA    WR4-3                                          STHA 168
 CPYLP  LXA    D(2),2                                         STHA 169
        PXA    ,1                                             STHA 170
        ADD    ADHD                                           STHA 171
        STA    HDSAV1                                         STHA 172
        STA    HDSAV2                                         STHA 173
        STA    HDSAV4                                         STHA 174
HDSAV1  CLA      ,2           SAVE                            STHA 175
        STO    HDSAV+2,2      LAST 2                          STHA 176
        CLA    PAGEN+2,2      WORDS OF                        STHA 177
HDSAV2  STO      ,2           HEADING                         STHA 178
        TIX    *-4,2,1                                        STHA 179
        CLA    *+1                                            STHA 180
        STO    HDSAV+2                                        STHA 181
        SXD    WR4+1,1                                        STHA 182
        CLA    ADHD                                           STHA 183
        STA    WR4+1                                          STHA 184
 WR4    TSX    WRITE,4                                        STHA 185
        PZE      ,,--                                         STHA 186
        NZT    HDSAV+2        WAS HEAD SAVED.                 STHA 187
        TRA    HDSAV3         NO.                             STHA 188
        STZ    HDSAV+2        YES. RESTORE                    STHA 189
        LXA    D(2),2         LAST 2 WORDS                    STHA 190
        CLA    HDSAV+2,2      OF HEADING                      STHA 191
HDSAV4  STO      ,2                                           STHA 192
        TIX    *-2,2,1                                        STHA 193
HDSAV3  LXD    WSV1,1                                         STHA 194
        CLA SBNHD                                             STHA 195
        STO BINHD                                             STHA 196
        LXD WSV2,2                                            STHA 197
        LXD WSV4,4                                            STHA 198
        TRA 2,4                                               STHA 199
WSV1    PZE                                                   STHA 200
WSV2    PZE                                                   STHA 201
WSV4    PZE                                                   STHA 202
SBNHD   PZE                                                   STHA 203
 HDSAV  BSS    2                                              STHA 204
        PZE    0                                              STHA 205
*HDTEST   TEST FOR PRINTING HEADING                           STHA 206
*TESTS IF HEADING SPECIFICATION HAS BEEN                      STHA 207
*CHANGED   IF SO WHETHER IT HAS BEEN                          STHA 208
*CANCELLED     IF NOT IT WRITES THE HEADING                   STHA 209
*RETURNS HDC =0 FOR NO HEADING  HDC=1 FOR ONE                 STHA 210
*SETS NL TO ZERO ANP UPDATES NP                               STHA 211
*ENTER BY                                                     STHA 212
*      TSX HDTST,4                                            STHA 213
*      NORMAL RETURN                                          STHA 214
HDTST   STZ R                                                 STHA 215
        STZ BOTLS                                             STHA 216
        CLA MBHD              HAS BINARY BUFFER BEEN          STHA 217
        CAS BINHD             CHANGED                         STHA 218
        TRA SETB              YES                             STHA 219
        CLA CHHD              NO HAS CALL HDING BEEN USED     STHA 220
        TNZ SETC              YES                             STHA 221
        CLA HDN               NO HAS CALL NOHEAD BEEN USED    STHA 222
        TNZ DONE1                                             STHA 223
STZH    STZ HDC                                               STHA 224
```

```
         CLA HDP                                           STHA 225
         TNZ WOPG                                          STHA 226
STZH1    CLA D54                                           STHA 227
         STZ HDN                                           STHA 228
         TRA SLPP                                          STHA 229
LBHD1    PZE BINHD                                         STHA 230
SETB     CAL BINHD          SET UP TO PRINT HEADING        STHA 231
         SLW TOPHD          1 IN COL 1                     STHA 232
         CLA LBHD1                                         STHA 233
         STA ADHD                                          STHA 234
         STA ADRHD                                         STHA 235
         CLA MBHD           RESTORE 1ST WORD               STHA 236
         STO BINHD          OF BINARY BUFFER               STHA 237
         TRA   DONE1                                       STHA 238
SETC     STZ CHHD                                          STHA 239
DONE1    SXD SV4,4                                         STHA 240
         TSX WRHD,4                                        STHA 241
D(1)     PZE 1                                             STHA 242
         LXD SV4,4                                         STHA 243
         CLA D52                                           STHA 244
         STO HDC                                           STHA 245
         STO HDN                                           STHA 246
SR       STO R                                             STHA 247
SLPP     STO LPP                                           STHA 248
         STO NLLFT                                         STHA 249
         CLA NP                                            STHA 250
         ADD D1                                            STHA 251
         STO NP                                            STHA 252
         STZ NL                                            STHA 253
         CLA R                                             STHA 254
         TNZ *+6                                           STHA 255
         CLA D19                                           STHA 256
         STO VECT2                                         STHA 257
         CLA D7                                            STHA 258
         STO VECT4                                         STHA 259
         TRA 1,4                                           STHA 260
         CLA D18                                           STHA 261
         STO VECT2                                         STHA 262
         CLA D6                                            STHA 263
         STO VECT4                                         STHA 264
         TRA 1,4                                           STHA 265
SV4      PZE                                               STHA 266
WOPG     LXA D(17),1                                       STHA 267
         SXD WOPG4,4                                       STHA 268
         TSX OTOD,4         GET PAGE IN BCI                STHA 269
         CLA IND72                                         STHA 270
         TNZ *+2            HDTST                          STHA 271
         TXI *+1,1,-8                                      STHA 272
         SXA   WR5,1                                       STHA 273
         PXA   ,1                                          STHA 274
         ADD   RECRD                                       STHA 275
         ADD   D(1)                                        STHA 276
         STA   WR6                                         STHA 277
         LXA   D(20),2      SAVE                           STHA 278
         CLA   REC+20,2     RECORD                         STHA 279
         STO   SVREC+20,2   BUFFER                         STHA 280
         TIX   *-2,2,1                                     STHA 281
```

```
         CLA    15BLK                                                STHA 282
         STO    REC                                                  STHA 283
         CLA    ALBLK                                                STHA 284
 WR6     STO      ,1                                                 STHA 285
         TIX    *-1,1,1                                              STHA 286
 WR5     AXT      ,1                                                 STHA 287
         LXA    D(2),2                                               STHA 288
         PXA    ,1                                                   STHA 289
         ADD    D(3)                                                 STHA 290
         PAX    ,1                                                   STHA 291
         PXA    ,1                                                   STHA 292
         ADD    RECRD                                                STHA 293
         STA    *+2                                                  STHA 294
         CLA    PAGEN+2,2                                            STHA 295
         STO      ,2                                                 STHA 296
         TIX    *-2,2,1                                              STHA 297
         SXD    WR7+1,1                                              STHA 298
         CLA    RECRD                                                STHA 299
         STA    WR7+1                                                STHA 300
 WR7     TSX    WRITE,4                                              STHA 301
         PZE      ,,--                                               STHA 302
         LXA    D(20),2          RESTORE                             STHA 303
         CLA    SVREC+20,2       RECORD                              STHA 304
         STO    REC+20,2         BUFFER                              STHA 305
         TIX    *-2,2,1                                              STHA 306
         CLA D53                                                 280 STHA 307
         STZ HDC                                                 281 STHA 308
         STZ HDN                                                 282 STHA 309
         LXD WOPG4,4                                             283 STHA 310
         TRA SR                                                  284 STHA 311
WOPG4    PZE                                                     285 STHA 312
 SVREC BSS    20                                                     STHA 313
*WRBF WRITE BUFFER ON TAPE                                       286 STHA 314
*ADDRESSES ARE STORED BY STH ETC.                                287 STHA 315
WRBF1    CAL BUF                                                 288 STHA 316
         ANA MSK                                                 289 STHA 317
         ORA M0,2                                                290 STHA 318
         SLW BUF                                                 291 STHA 319
WRBF2    SXD W4,4                                                292 STHA 320
         CLA    NWDS                                                 STHA 321
         STD    WR8+1                                                STHA 322
         CLA    BUFNW                                                STHA 323
         STA    WR8+1                                                STHA 324
 WR8     TSX    WRITE,4                                              STHA 325
         PZE      ,0,--                                              STHA 326
         LXD W4,4                                                298 STHA 327
         CAL VECT,2                                              299 STHA 328
         ADD NL                                                  300 STHA 329
         STD NL                                                  301 STHA 330
         CLA LPP                                                 302 STHA 331
         SUB NL                                                  303 STHA 332
         STD NLLFT                                               304 STHA 333
         CAL VECT2                                               305 STHA 334
         SUB VECT,2                                              306 STHA 335
         TZE *+2                                                 307 STHA 336
         TPL *+2                                                 308 STHA 337
         ADD D18                                                 309 STHA 338
```

```
       STO VECT2                                          STHA 339
       SUB D6                                             STHA 340
       TZE *+2                                            STHA 341
       TPL *-2                                            STHA 342
       ADD D6                                             STHA 343
       STO VECT4                                          STHA 344
       TRA 1,4                                            STHA 345
W4     PZE                                                STHA 346
*PNUM PROCESS BLANK, 2, 4, 0,                             STHA 347
PNUM   STZ R                 0 TO RESTORE INDICATOR       STHA 348
       TSX ELFT,4            TEST IF LINES LEFT           STHA 349
       TRA NOT               NO                           STHA 350
       TSX WRBF2,4           YES WRITE BUFFER             STHA 351
       TRA OUT                                            STHA 352
NOT    LXA D(1),2            REPLACE COL 1 BY 1           STHA 353
       TRA P1                                             STHA 354
*ILLGL   PROCESS ILLEGAL CHARACTER                        STHA 355
TOILG  TRA NILL1+1                                        STHA 356
ILLGL  CLA TOILG                                          STHA 357
       STO BACK                                           STHA 358
       LXA D(6),2                                         STHA 359
       TSX ELFT,4            4LINES LEFT                  STHA 360
       TRA NILL              NO                           STHA 361
       LXA D(0),2            YES                          STHA 362
NILL1  TSX WRBF1,4           WRITE LINE WITH BLANK        STHA 363
       CAL ILMSK                                          STHA 364
       ANS ILCH+3                                         STHA 365
       CAL CONT                                           STHA 366
       ALS 12                ILLGL                        STHA 367
       ORS ILCH+3                                         STHA 368
       CLA ELFT+4                                         STHA 369
       STO BACK                                           STHA 370
       LXD X4,4                                           STHA 371
       SXD XX4,4                                          STHA 372
       LXD X2,2                                           STHA 373
       LXD X1,1                                           STHA 374
       TSX    STHB,4                                      STHA 375
LILCH  PZE ILCH,0,10                                      STHA 376
       LXD XX4,4                                          STHA 377
       TRA 2,4                                            STHA 378
XX4    PZE                                                STHA 379
NILL   LXA D(1),2                                         STHA 380
       TRA P1                                             STHA 381
*OTOD   OCTAL TO DECIMAL INTEGER                          STHA 382
*SETS UP 2 WORDS OF BCI *  PAGE XXXX *                    STHA 383
*CALL                                                     STHA 384
*     TSX OTOD,4                                          STHA 385
OTOD   SXD OS4,4                                          STHA 386
       CLA 50BLK                                          STHA 387
       STO PGN                                            STHA 388
       LXA D(30),4                                        STHA 389
       CLA NP                                             STHA 390
       ARS 18                                             STHA 391
       LRS 35                NP TO MQ                     STHA 392
DV10   DVP D(10)             N(I)/10                      STHA 393
       ALS 36,4              SHIFT REMAINDER              STHA 394
       TXI *+1,4,-6                                       STHA 395
```

```
       ORS PGN                  MASK INTO PGN                         STHA 396
       STQ T                                                          STHA 397
       CLA T                                                          STHA 398
       TZE INSB                                                       STHA 399
       PXD                                                            STHA 400
       TRA DV10                                                       STHA 401
INSB   LDQ PGN                                                        STHA 402
       LXA D(5),4                                                     STHA 403
       PXD                                                            STHA 404
       LGL 6                                                          STHA 405
       TNZ *+2                                                        STHA 406
       TIX *-2,4,1                                                    STHA 407
       TXI *+1,4,-1                                                   STHA 408
       CAL PGNM,4                                                     STHA 409
       ORS PGN                                                        STHA 410
       LXD OS4,4                                                      STHA 411
       TRA 1,4                                                        STHA 412
       PZE                      0 LEADING BLANKS      THESE           STHA 413
       BCD 1 00000              1     *      *      MUST BE         STHA 414
       BCD 1  0000              2     *      *      IN THIS         STHA 415
       BCD 1   000              3     *      *      IDENTICAL       STHA 416
PGNM   BCD 1    00              4     *      *      ORDER           STHA 417
OS4    PZE                                                            STHA 418
T      PZE                                                            STHA 419
*RESTO  PAPER WILL BE RESTORED BEFORE                                 STHA 420
*NEXT LINE IS WRITTEN                                                 STHA 421
*USAGE                                                                STHA 422
*      CALL RESTO                                                     STHA 423
RESTO  SXD X4,4                                                       STHA 424
       TRA BOT.2                                                      STHA 425
*PAGES   RETURNS THE CURRENT PAGE NUMBER                              STHA 426
*USAGE                                                                STHA 427
*      CALL PAGES(NP)    CURRENT PAGE NO TO NP                        STHA 428
*PAGES AND LINES                                                      STHA 429
 PAGES CLA   1,4                                                      STHA 430
       STA *+3                                                        STHA 431
       CLA NP                                                         STHA 432
       SUB D1                                                         STHA 433
       STO                                                            STHA 434
       TRA 2,4                                                        STHA 435
*LINES  RETURNS THE NUMBER OF LINES                                   STHA 436
*PRINTED SO FAR ON THE CURRENT PAGE                                   STHA 437
*USAGE                                                                STHA 438
*      CALL LINES(NL)    NO. OF LINES TO NL                           STHA 439
 LINES CLA   1,4                                                      STHA 440
       STA *+2                                                        STHA 441
       CLA NL                                                         STHA 442
       STO                                                            STHA 443
       TRA 2,4                                                        STHA 444
*NEWSET RESETS PAGE NUMBER TO ARGUMENT(NP)                            STHA 445
*AND SETS INDICATOR TO PRINT PAGE NUMBER                              STHA 446
*USAGE                                                                STHA 447
*      CALL NEWSET(NP)   NEXT PAGE WILL BE NP                         STHA 448
NEWSET CLA   1,4                                                      STHA 449
       STO HDP                                                        STHA 450
       STA *+1                                                        STHA 451
       CLA                                                            STHA 452
```

```
       SSP
       STO NP
       TRA 2,4
*HDING INITIALIZES STH TO WRITE
*SPECIFIED HEADING  SETS CHHD=1
*USAGE
*      CALL HDING(A)    WHERE A IS THE INITIAL
*                          LOCATION OF 120 BCI CHARACTERS
*OR    CALL HDING(120H ...HEADING...)
*HDING  PROCESS CALL HDING(A)
*INITIALIZES FOR HEADING COPY LOOP
HDING   CLA 1,4
        STA ADHD
        STA ADRHD
        CLA MBHD
        STO CHHD
        STO BINHD
        TRA 2,4
*COLUMN   INITIALIZES PRINTOUT OF PAGE
*NUMBER FOR 72 OR 120 COLUMN PRINTOUT
*IF NOT SPECIFIED 120 IS ASSUMED
*USAGE
*      CALL COLUMN(N)    N=72 FOR 72COL.
*                         N NOT =72 FOR 120
COLUMN CLA   1,4
       STA *+1
       CLA
       SUB D72
       STO IND72
       TRA 2,4
*NOPAGE   INIALIZES STH TO OMIT WRITING
*PAGE NUMBER
*USAGE
*      CALL NOPAGE
NOPAGE STZ    HDP
       TRA 1,4
*NOHEAD   INITIALIZES STH TO OMIT WRITING
*HEADING BEGINNING WITH NEXT PAGE
*USAGE
*      CALL NOHEAD
NOHEAD STZ    CHHD
       STZ HDN
       CLA MBHD
       STO BINHD
       TRA 1,4
*BOTTOM   PRINTS HEADING IF THERE IS
*ONE AT BOTTOM OF PAGE AND SETS LINE CTR
*USAGE
*      CALL BOTTOM
*BOTTOM WRITES HEADING AT BOTTOM
BOTTOM SXD    X4,4
       CLA BOTLS
       TNZ BOT.2
       SXD BOTLS,4
       CLA HDC
       TZE BOT.1
       TSX WRHD,4
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        PZE                                                         481 STHA 510
BOT.2   STZ NLLFT                                                   482 STHA 511
        CLA LPP                                                     483 STHA 512
        STO NL                                                      484 STHA 513
        LXD X4,4                                                    485 STHA 514
        TRA 1,4                                                     486 STHA 515
BOT.1   CLA NLLFT                                                   487 STHA 516
        TZE BOT.2+1                                                 488 STHA 517
        CLA   85BLK                                                     STHA 518
        STO   REC                                                       STHA 519
        TSX   WRITE,4                                                   STHA 520
        PZE   REC,,1                                                    STHA 521
        TRA BOT.2                                                   492 STHA 522
85BLK   BCD 18                                                      493 STHA 523
*IPM AND FPM                                                        494 STHA 524
ANPIPM CAL    TS1P8                                                     STHA 525
        SLW STH1                                                    501 STHA 526
IPMP8   CLA 1,4                                                     502 STHA 527
        SXD PMSV4,4                                                 503 STHA 528
        TNZ FPM                                                     504 STHA 529
        CLA STH1                                                    505 STHA 530
        STO SVSH1                                                   506 STHA 531
        CLA TOPM1                                                   507 STHA 532
        STO STH1                                                    508 STHA 533
        TSX   BOTTOM,4                                                  STHA 534
        CLA   15BLK                                                     STHA 535
        STO   REC                                                       STHA 536
        TSX   WRITE,4                                                   STHA 537
        PZE   REC,0,1                                                   STHA 538
        LXD PMSV4,4                                                 513 STHA 539
        TRA 2,4                                                     514 STHA 540
TOPM2   TTR PM2                                                     515 STHA 541
PMSV4   PZE                                                         516 STHA 542
TOPM1   TTR PM1                                                     517 STHA 543
SVSH1   PZE                 ORIGINAL STH1                           518 STHA 544
PM1     CLA 1,4                                                     519 STHA 545
        STA *+5                                                     520 STHA 546
        STA *+1                                                     521 STHA 547
        CAL                                                         522 STHA 548
        ANA MSK                                                     523 STHA 549
        ORA MBL                                                     524 STHA 550
        SLW                                                         525 STHA 551
        CLA TOPM2                                                   526 STHA 552
        STO STH1                                                    527 STHA 553
PM2     CLA    1,4                                                      STHA 554
        STO    WR9+1                                                    STHA 555
        SXD       X4,4
WR9     TSX    WRITE,4                                                  STHA 556
        PZE       ,,--                                                  STHA 557
        LXD       X4,4
        TRA       2,4
FPM     CLA SVSH1           RESTORE ORINAL                          540 STHA 558
        STO STH1            STH1                                    541 STHA 559
        TRA 2,4                                                     542 STHA 560
*LOCATION SYMBOLS                                                   543 STHA 561
NL      PZE                 NUMBER OF LINES PRINTED                 544 STHA 562
R       PZE                 RESTORE INDICATOR          248          545 STHA 563
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HDC      PZE                        CURRENT HEADING INDICATOR     546 STHA 564
NLLFT    PZE                        LINES LEFT                    547 STHA 565
BOTHD    PZE                                                      548 STHA 566
TOPHD    PZE                                                      549 STHA 567
PAGEN    BCD 1  PAGE                                              550 STHA 568
PGN      PZE                        PAGE NUMBER IN DECIMAL        551 STHA 569
LPP      PZE                        LINES PER PAGE                552 STHA 570
15BLK    BCD 11                                                   553 STHA 571
5)BLK    BCD 100000                                               554 STHA 572
*MASKS FOR ADDINING CONTROL CHARACTER                             555 STHA 573
MSK      OCT 007777777777                                         556 STHA 574
MBHD     OCT 376060606060                                         557 STHA 575
ALBLK    BCD 1                                                    558 STHA 576
Z5BLK    BCD 10                                                   559 STHA 577
DMSK     OCT 077777000000                                         560 STHA 578
ILMSK    OCT  377777007777                                        561 STHA 579
         BCD 1100000                                              562 STHA 580
M8       BCD 1800000                                              563 STHA 581
         PZE                                                      564 STHA 582
         PZE                                                      565 STHA 583
M4       BCD 1400000                                              566 STHA 584
MBL      BCD 1 00000                BLANK                         567 STHA 585
M2       BCD 1200000                                              568 STHA 586
M1       BCD 1100000                                              569 STHA 587
M0       BCD 1000000                                              570 STHA 588
NWDS     PZE                        NUMBER OF WORDS               576 STHA 589
BUF      PZE                        ADDRESS FOR COPY LOOP         577 STHA 590
1STWD    PZE                        1ST WORD OF OUTPUT            578 STHA 591
X4       PZE                        ORIGINAL C(4)                 575 STHA 592
X2       PZE                        ORIGINAL C(2)                 579 STHA 593
X1       PZE                        ORIGINAL C(1)                 580 STHA 594
CONT     PZE                        CONTROL FROM PROGRAM          581 STHA 595
ILCH     BCD 50CONTROL CHARACTER * C * OF PR                      582 STHA 596
         BCD 5ECEDING LINE IS NOT LEGAL                           583 STHA 597
         TXL P8                     8                             584 STHA 598
         TXL ILLGL                  7                             585 STHA 599
         TXL ILLGL,0,0              5 LATER PLUS                  587 STHA 60
         TXL ILLGL,0,4              6 STAYS ILLGL                 586 STHA 60
         TXL PNUM,0,6               4                             588 STHA 60
         TXL ILLGL,0,1              3 LATER BLANK                 589 STHA 60
         TXL PNUM,0,18              2                             590 STHA 60
         TXL P1,0,1                 1                             591 STHA 60
SET      TXL PNUM,0,2               0                             592 STHA 60
         BCD 14                     6 LINES                       593 STHA 60
         BCD 10                     2 LINES                       594 STHA 60
1WD      BCD 1                      1 LINE                        595 STHA 60
*CONSTANTS IN ADDRESS PORTION                                     596 STHA 61
D(2)     PZE 2                                                    597 STHA 61
D(3)     PZE 3                                                    598 STHA 61
D(5)     PZE 5                                                    599 STHA 61
D(6)     PZE 6                                                    600 STHA 61
D(10)    PZE 10                                                   601 STHA 61
D(17)    PZE 17                                                   602 STHA 61
D(19)    PZE 19                                                   603 STHA 61
D(20)    PZE 20                                                   604 STHA 61
D(24)    PZE 24                                                   605 STHA 61
D(30)    PZE 30                                                   606 STHA 62
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D(32)   PZE 32                                                     607 STHA 621
D(36)   PZE 36                                                     608 STHA 622
D(48)   PZE 48                                                     609 STHA 623
D(52)   PZE 52                                                     610 STHA 624
*CONSTANTS IN DECREMENT                                            611 STHA 625
D1      PZE ,0,1                                                   612 STHA 626
D5      PZE ,0,5                                                   613 STHA 627
D6      PZE ,0,6                                                   614 STHA 628
D7      PZE ,0,7                                                   615 STHA 629
D17     PZE ,0,17                                                  616 STHA 630
D18     PZE ,0,18                                                  617 STHA 631
D19     PZE ,0,19                                                  618 STHA 632
D72     PZE ,0,72                                                  619 STHA 633
TIP8    TTR IPMP8                                                  621 STHA 634
TS1P8   TTR STH18                                                  622 STHA 635
 TOSTH TTR    STHB                                                     STHA 636
*NEW VECTOR FOR LINES REQUIRED                                     623 STHA 637
VECT6   PZE ,0,4                 4 LINES FOR ILLEGAL CHAR.         624 STHA 638
VECT5   PZE ,0,0                 0 LINES FOR +                     625 STHA 639
VECT4   PZE                      VARIABLE NUMBER FOR 4             626 STHA 640
VECT3   PZE ,0,1                 1 LINE FOR BLANK                  627 STHA 641
VECT2   PZE                      VARIABLE NUMBER FOR 2             628 STHA 642
VECT1   PZE ,0,1                 1 LINE FOR RESTORE                629 STHA 643
VECT    PZE ,0,2                 2 LINES FOR 0                     630 STHA 644
SVV4    PZE                                                        632 STHA 645
BOTLS   PZE                      NON-ZERO IF BOT. HD WAS LAST      633 STHA 646
 1      PZE    0                                                       STHA 647
 BUFNW PZE     0                                                       STHA 648
        REM                                                            STHA 649
        REM    THIS ROUTINE WRITES AN N WORD                           STHA 650
        REM    RECORD STARTING AT LOCATION M.                          STHA 651
        REM    TSX    WRITE,4                                          STHA 652
        REM    PZE    M,0,N                                            STHA 653
        REM                                                            STHA 654
 WRITE  CLA    1,4             BUFFER ADDRESS,0,NO. OF WORDS.          STHA 655
        STO    WR+1                                                    STHA 656
        STA    REC1                                                    STHA 657
        SXA    WR1,4           SAVE IR4.                               STHA 658
 WR     TSX    STHW,4                                                  STHA 659
        PZE      ,0,--                                                 STHA 660
 WR1    AXT      ,4                                                    STHA 661
        CLA    RECRD           RESTORE REC IN ADDRESS.                 STHA 662
        STA    REC1                                                    STHA 663
        TRA    2,4             OUT.                                    STHA 664
 RECRD  PZE    REC                                                     STHA 665
        REM                                                            STHA 666
 (STH)  LDQ    *+2             PICKUP SWITCH SETTING, AND              STHA 667
        TRA*   $(IOH)          GO INITIALIZE (IOH).                    STHA 668
        TRA    STH             OUTPUT / STORAGE TO TAPE HOLLERITH.     STHA 669
(STHM)  LDQ    *+2             PICKUP SWITCH SETTING, AND              STHA 670
        TRA*   (IOH)           GO INITIALIZE IOH.                      STHA 671
        TRA    STHM            OUTPUT / TAPE MONITOR.                  STHA 672
        REM                                                            STHA 673
 STHM   CAL    37              INCREASE                                STHA 674
        ADM    TES+2           LINE COUNT                              STHA 675
        STA    37              BY 1.                                   STHA 676
        REM                                                            STHA 677
```

```
 STH    TTR    STHA
 STHW   SXA    STHX,4           SAVE RETURN INDEX.
 TES    TSX    $(WER),4         GO CHECK PREVIOUS WRITE.
        LXA    STHX,4
        CAL    1,4              SET WORD COUNT
        STD    STHC             OF WRITE COMMAND.
        AXT    0,4
        SXA    *+6,2            MOVE
        PDX    ,2               RECORD
 REC1   CAL    REC,4            INTO
        SLW    OUTPUT,4         OUTPUT
        TXI    *+1,4,-1         BUFFER.
        TIX    *-3,2,1
        AXT      ,2
        CAL    TES              SET SWITCH FOR
        SLW*   $(TES)           WRITE OVERLAP.
        XEC*   $(WRS)           SELECT CURRENT UNIT.
        AXC    STHC,4           INITIALIZE
        PXA    ,4               FOR
        STA*   $(WTC)           WRITE CHECKING.
        XEC*   $(RCH)           WRITE ONE TAPE RECORD.
 STHX   AXT      ,4             RESTORE RETURN INDEX.
        TRA    2,4              EXIT TO IOH.
        REM
        REM
 STHC   IOST   OUTPUT,,--       WRITE COMMAND
OUTPUT  BSS    20               OUTPUT BUFFER
        COMMON   -205+20                   WAS  206
 REC    COMMON   1              RECORD BUFFER
        REM
        END


*WOT -- WRITE OUTPUT TAPE       NOV 1960
        COUNT    100
        ENTRY    WOT
*
*          FORTRAN 2 LIBRARY SUBROUTINE WOT
*
*          WOT REQUIRES (LEV),(FIL),(STH), AND (SPH) TO BE IN THE
*
*          CALLING SEQUENCE
*
*          CALL WOT (N)
*
*
*          THE WOT SUBROUTINE WILL CONTROL ALL PRINT AND/OR
*          WRITE OUTPUT TAPE STATEMENTS IN THE PROGRAM WHICH
*          OCCUR LOGICALLY AFTER THE FIRST USE OF THE WOT
*          SUBROUTINE.   THE ARGUMENT USED WILL APPLY UNTIL
*          ANOTHER CALL WOT (N) STATEMENT IS USED TO CHANGE
*          THE ARGUMENT TO ANOTHER VALUE.   EITHER AN INTEGER
*          OR AN INTEGER VARIABLE MAY BE USED FOR THE
*          ARGUMENT THUS ALLOWING THE PROGRAMMER TO FIX THE
*          OUTPUT OR TO PLACE IT UNDER CONTROL OF AN INPUT
*
```

```
*          WITH A DIFFERENT INTEGER VARIABLE IN THE ARGUMENT
*          PRIOR TO EACH SET OF OUTPUT COMPLETE CONTROL OF
*          EACH SET OF OUTPUT MAY BE MADE A FUNCTION OF INPUT.
*          REGARDLESS OF WHETHER A PRINT OR A WRITE OUTPUT
*          TAPE STATEMENT WAS USED, OUTPUT WILL BE GIVEN ON
*          TAPE 3 AND/OR THE PRINTER ACCORDING TO THE
*          FOLLOWING SCHEME ---
*
*
*          ARGUMENT                OUTPUT ON
*          OF   WOT          TAPE 3               PRINTER
*
*
*             1                YES                   YES
*             2                YES               IF SW3 DOWN
*             3                YES                   NO
*             4            IF SW3 UP                 YES
*             5            IF SW3 UP             IF SW3 DOWN
*             6            IF SW3 UP                 NO
*             7                NO                    YES
*             8                NO                IF SW3 DOWN
*             9                NO                    NO
*
*
*
*
*
*
*
*
 WOT    CAL     TRWOTB            ENTRY FOR FIRST
        SLW*    $(STH)            OCCURRENCE OF CALL WOT
        CAL     TRWTB1
        SLW*    $(SPH)
        CAL     TRWOTA            SET TYPE ROUTINES TO
        SLW     WOT               BRING IN WOT
        CAL     $(STH)
        ADD      =3                     INITIALIZE JUMPS
        STA     TRASH             FROM IOH
        CAL     $(SPH)
        ADD     FIVE
        STA     TRASP
 WOTA   CLA*    1,4               ENTRY FOR SUCCEEDING
        ARS     18                CALL WOTS
        ADD     *+6
        STA     *+1               LOOK UP IN TABLE AND
        CLA                       SET TRIGGERS FOR
        STA     TCON              WRITE-PRINT OPTIONS
        STD     PCON
        TRA     2,4               BACK TO MAIN
        HTR     *
        PZE     2,0,2             ADDR.=1 WRITE IF SW3 UP
        PZE     2,0,1             ADDR.=2 WRITE
        PZE     2,0,3             ADDR.=3 DONT WRITE
        PZE     1,0,2
        PZE     1,0,1             DECR.=1 PRINT IF SW3 DOWN
        PZE     1,0,3             DECR.=2 PRINT
```

```
        PZE    3,0,2             DECR.=3 DONT PRINT
        PZE    3,0,1
        PZE    3,0,3
WOTB1   CAL     DECR3                  ENTRY FROM SPH
WOTB    SLW     UNIT                   ENTRY FROM STH
        SXD     IX4,4
        CLA    TCON
        SUB    TWO               TEST WRITE TRIGGER
        TZE    WRITE
        TPL    SKIPT
        SWT    SWCH3
        TRA    WRITE
 SKIPT  CLA    TWO
        STO    SKCON
        TRA    WOTD              GO TO TEST PRINT
 WRITE  STZ    SKCON
        CAL*   $(FIL)            SET FIL TO BRING IN WOT
        SLW    CFIL
        CAL    TRWOTC
        SLW*   $(FIL)
        LDQ    TRASH             INITIALIZE FOR
        CAL    UNIT              WRITING AND
        TRA*    $(IOH)
 WOTC   SXD    IN4,4             ENTRY FROM FIL
        CAL    CFIL              RESTORE FIL AND
        SLW*   $(FIL)            GO BACK, BUT RETURN
        TSX    $(FIL),4          WILL BE TO WOTD
 WOTD   CLA    PCON
        ARS    18
        SUB    TWO               TEST PRINT TRIGGER
        TZE    PRINT
        TPL    SKIPP
        SWT    SWCH3
        TRA    SKIPP
 PRINT  LXD    IX4,4             SET INDEX FOR RETURN
        LDQ    TRASP             TO FIRST INSTR AFTER
        CLA    DECR3             TSX TYPE.  INITIALIZE
        TRA*    $(IOH)
 SKIPP  CLA    SKCON             WE DIDNT PRINT
        TNZ    SKIPPD            DID WE WRITE
        LXD    IN4,4             YES RETURN TO FIRST
        TRA    1,4               INSTR AFTER TSX FIL
SKIPPD  LXD     IX4,4
        CAL     2,4                    NO FLIP THROUGH
        STA     *+1                    AND LOOK FOR IT
        CLA
        SUB    $(FIL)            GO THERE
        TZE    EXIT
        TXI     SKIPPD+1,4,-1
EXIT    TRA     3,4                    THEN TRANSFER
TRWOTA  TRA    WOTA
TRWOTB  TRA    WOTB
TRWTB1  TRA    WOTB1
TRWOTC  TRA    WOTC
TRASH   TRA
 TRASP  TRA
 TWO    DEC     2
```

```
FIVE   DEC     5
TCON   PZE
PCON   PZE
UNIT   PZE
SKCON  PZE
CFIL   PZE
IN4    PZE
IX4    PZE
DECR3  MZE     ,,3
SWCH3  EQU     3
       END
```